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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

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See Full Page Advt., page 84, Dec. 10.

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Forgings, Castings, Bars, Sheets, Wire, Tubes.
THE DELTA METAL CO., LTD., 8477
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See Full Page Advertisement page 76, Dec 10.

Diesel Engines, Six Cylinder, two and four stroke, 880, 1040, 1200 H.P. Excellent condition. Dynamos for above 250 or 500 Volts, D.C. Immediate delivery and low price.
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Machine and Engineering WORK of all descriptions undertaken for Manufacturers, Patentees, &c. Also repairs and renewals. Best work, moderate charges.—ROSSER & RUSSELL, LTD., Queen's Wharf, Hammersmith.
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Dredging Plant OF ALL DESCRIPTIONS.
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Agents: MARINE WORKS, LTD., Palace House, 39-41, New Broad St., LONDON, E.C. 2.
See half-page Advert. last week and next week. 8490

Centrifugals.
Pott, Cassels & Williamson,
MOTHERWELL, SCOTLAND. 8809
See half-page Advertisement, page 109, Nov. 26.

The Manchester Steam Users' ASSOCIATION.

For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, MOUNT STREET, MANCHESTER.
Chief Engineer: C. E. STROMEYER, M.I.C.E.
Founded 1854 by SIR WILLIAM FAIRBAIRN.
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Inst. C.E., I. Mech. E., B.Sc.,

and all Engineering Examinations.—Mr. G. P. KNOWLES, B.Sc., M.E.E., A.M.Inst.C.E., F.S.I., M.R.San.I., PREPARES CANDIDATES personally or by correspondence. Hundreds of successes. Courses may commence at any time.—39, Victoria St., Westminster, S.W. Tel. 4780 Victoria. 8970

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UNIVERSITY ENGINEERING COLLEGE,
Westgate-on-Sea, Kent. K 851

TENDERS.

SIMLA WATERWORKS EXTENSION SCHEME.

GUMA SCHEME.

CONTRACT No. 3.

The Municipal Committee, Simla, invite

Tenders for Supplying,

ERECTING and RUNNING for one month a NEW PUMPING PLANT, consisting of three units and steel rising mains, etc., with all fittings for the water supply. The pump lift (excluding friction) is 309 feet. The Municipal Committee are also prepared to consider alternative Tenders for other forms of plant to do the duty required by the Specification. Plans may be seen and the Specification, Bill of Particulars and Form of Tender obtained on written enquiry addressed to A. F. HENDERSON, Esq., c/o Messrs. HENRY S. KING & Co., Cornhill, E.C., on payment of £1 only. Tenders which must be on forms provided with Bill of Particulars and Schedule fully priced out, must be sent in sealed cover addressed to the Secretary, Municipal Offices, Simla, and must be received by him before Four p.m. on the 28th March, 1921.
The Municipal Committee do not bind themselves to accept the lowest or any Tender.
Parties tendering do so at their own cost.
A. LANGLEY,
President, Municipal Committee.
Dated Simla, the 15th November, 1920. L 119

BATTERSEA BOROUGH COUNCIL.
ELECTRICITY DEPARTMENT.

The Council invite

Tenders for Pipework for a

5000 Kw. Turbo Alternator.
Specification and Form of Tender may be obtained from the Electrical Engineer, Electricity Works, Lombard Road, Battersea, S.W.11. Additional copies of the Specification and Form of Tender may be obtained on payment of 5/- for each copy, which sum will not be refunded. Tenderers must pay the Trade Union rates of wages, &c., in all departments.
The Council do not bind themselves to accept the lowest or any Tender.
Tenders, sealed and endorsed "Tender for Pipework," must be delivered to the undersigned by Twelve Noon on Wednesday, the 5th January, 1921.
EDWIN AUSTIN,
Town Clerk.
11th December, 1920. L 301

JHARIA WATER SUPPLY SCHEME.

TENDERS FOR PIPES, &c.

Tenders are Invited for the

SUPPLY and DELIVERY of CAST IRON PIPES, up to 21 inches internal diameter, together with SLUICE STOP VALVES, &c. The total weight of pipes will be about 14,000 tons. Sealed Tenders accompanied by a deposit of £250 Sterling will be received at the office of Messrs. SIR ALEX. BINNIE, SON & DEACON, 35, Buckingham Gate, Victoria Street, Westminster, S.W.1, up to mid-day on the 31st JANUARY, 1921.
Two copies of the Form of Tender, Contract Agreement, Specification, and Bills of Quantities may be obtained by sending in an application, with a deposit of £5 Sterling, to Messrs. SIR ALEX. BINNIE, SON & DEACON, and such deposit will be refunded when a *bona fide* Tender, accompanied by the Specification, &c., has been received by the Chairman of the Jharia Water Board. The Board does not bind itself to accept the lowest or any Tender.
R. S. HORNBLE,
Chairman of the Jharia Water Board,
Dhanbad, B.N.R. (India). L 238

Tenders are Invited for One

MODERN WHEEL PRESS, to take axles up to 6 in. dia. by 7 ft. long, wheels 4 ft. 3½ in. gauge.
Please supply full particulars, to the
CHIEF MECHANICAL ENGINEER,
SOUTH METROPOLITAN GAS COMPANY,
709, Old Kent Road,
London, S.E.15. L 101

HONG KONG.
PUBLIC WORKS DEPARTMENT.

PUMPING MACHINERY, ETC.

THE CROWN AGENTS FOR THE COLONIES invite

Tenders for the Manu-

FACTURE and DELIVERY F.O.B. of the following, for the Public Works Department, Hong Kong.
A Horizontal Triple-expansion or other type of STEAM ENGINE, coupled direct to high and low lift pumps, to lift to a height of 1625 ft. and 565 ft. respectively, with a Lancashire Boiler, Superheater, Pipe-work, Valves, and other accessories.
Specification, General Conditions, &c., and Form of Tender, may be obtained from the Chief Engineer, at the Office of the Crown Agents for the Colonies, 4, Millbank, Westminster, on or after the 13th December, 1920.
A deposit of £5 will be required and will be refunded on receipt of a *bona fide* Tender.
Drawings may be inspected and further particulars obtained on application at the Office of Mr. WILLIAM FAIRLEY, M.Inst.C.E., Parliament Mansions, S.W.
Tenders to be lodged on or before 12th January, 1921, endorsed "Tender Pumping Machinery, Hong Kong—Requisition No. 2493." L 186

British Automobile Equip-

MENT COMPANY, LIMITED.

HIGHFIELD WORKS, FELTHAM, MIDDLESEX.

FOR SALE,
INVITATION FOR TENDERS.

FULLY EQUIPPED FREEHOLD FACTORY, PARTICULARLY SUITED TO MOTOR, METAL, TOOL AND ENGINEERING TRADES.
The works are situated at Feltham, Middlesex, about 14 miles from Waterloo, and adjoin the London and South-Western Railway. The land covers approximately two acres, and is freehold. The buildings, which are of brick, designed and arranged to fulfil the demands of modern production, comprise a floor space of about 34 000 ft.
The works are fully equipped and ready for immediate operation. They contain:—
Machine Tools, Lathes, Capstan and Turret Lathes, Planing Machines, Horizontal and Vertical Machines, Power and Fly Presses, Treadle and Power Guillotine, Rolls, Gray's Sheet Metal Cutter, &c.
There is also woodworking machinery, spindle planer and thicknesser, circular saw, band saw, generating plant, 100 HP. Stockport gas engine, suction gas plant, electric light, &c.
The factory and contents can be inspected by appointment.
Tenders must be delivered sealed to the Receiver on or before Friday, the 31st day of December, 1920, at Twelve o'clock Noon, and marked on the envelope "Tender for Highfield Works, Feltham."
The Receiver does not bind himself to accept the highest or any Tender, and reserves to himself all rights in connection therewith.
Forms of Tender may be obtained of
SIR BASIL B. MATHEW, K.B.E., F.C.A.,
Receiver,
Alderman's House, Bishopsgate, E.C. 2,
and forms of the contract, which tenderers will be required to sign if their Tender is accepted, and forms and schedules of the plant and machinery comprised in the sale may be seen at the same place.
6th December, 1920. L 173

SOUTH AFRICAN RAILWAYS AND HARBOURS.

PRELIMINARY NOTICE TO CONTRACTORS.

GRAIN ELEVATORS.

Tenders are Invited for the

CONSTRUCTION of
(a) ONE TERMINAL GRAIN ELEVATOR at Cape Town, capacity 30,000 tons of 2,000 lbs.
(b) ONE TERMINAL GRAIN ELEVATOR at Durban, capacity 42,000 tons of 2,000 lbs.
(c) THIRTY-FOUR COUNTRY ELEVATORS, ranging in capacity from 1,800 to 5,800 tons of 2,000 lbs.
The drawings consist of approximately 150 sheets and a preliminary set, subject to slight modifications, will be available for inspection by intending tenderers at:—
The Office of the HIGH COMMISSIONER FOR THE UNION OF SOUTH AFRICA, 32, Victoria Street, London, on and after the 22nd of December, 1920.
or, The Office of the ENGINEER-IN-CHIEF, Johannesburg or the Assistant General Managers at Cape Town or Durban, on and after the 6th of December, 1920.
Contractors in Great Britain and abroad who desire to obtain a set of the drawings and documents forming the basis of tenders, must notify the High Commissioner immediately and contractors in South Africa must similarly notify the Engineer-in-Chief, Railway Headquarters Offices, Johannesburg.
The requisite number of complete copies of drawings and documents will then be printed, and it is expected that these will be available in London on or about the 28th of January, and in South Africa on or about the 10th of January.
A deposit of £100 will be required for a complete set of drawings and documents covering the terminal elevators at Cape Town and Durban, and a similar deposit of £20 will be required for the drawings and documents for the country elevators.
Of the required deposits 20 per cent. must be paid on making requisition for copies of the contract drawings and documents and the balance when these are handed over.
Contractors submitting *bond fide* Tenders and returning therewith all the drawings and documents, will be entitled to a refund in full of the above deposits.
Tenders are to be lodged in London by Noon on Monday, the 2nd of May, 1921.
The Administration does not bind itself to accept the lowest or any Tender.
FULL PARTICULARS WILL BE PUBLISHED LATER. L 311

BOROUGH OF POOLE.

POOLE WATERWORKS.

Contract No. 3.
BOREHOLES.

The Corporation of Poole invite

Tenders for the Work Re-

QUIRED in the SINKING of TWO 21 inches diameter BOREHOLES at the Poole Waterworks Pumping Station, situated at Corfe Mullen, about three miles from Broadstone Junction, on the London and South Western Railway, in the County of Dorset, in accordance with the Plans and Specification prepared by the Engineer, Mr. A. F. I. COTTERELL, M.Inst.C.E., of 17, Old Queen Street, Westminster, S.W. 1.
Specification, Forms of Tender, Drawings, &c., may be seen at the Offices of the Engineer, Mr. A.F.I. COTTERELL, M.Inst.C.E., 17, Old Queen Street, Westminster, S.W. 1, on or after the 20th day of December, 1920, during the usual office hours.
Contractors wishing to Tender may obtain copies of the Specification, Form of Tender and Schedule of Prices, Drawings, &c., from the Engineer on payment of the sum of £5 5s. 0d., which will be returned on receipt of *bona fide* Tender and all plans and documents supplied.
Tender on the Forms provided, enclosed in sealed envelopes, addressed to the undersigned and endorsed "Poole Waterworks—Contract No. 3," must be delivered not later than 10 a.m. on the 17th day of January, 1921.
The Corporation do not bind themselves to accept the lowest or any Tender.
By Order,
CHARLES LISBY,
Town Clerk
Municipal Buildings,
Poole, Dorset. L 243

APPOINTMENTS OPEN.

UNIVERSITY OF LONDON.

The Senate invite

Applications for the

CHADWICK (part-time)
CHAIR OF MUNICIPAL ENGINEERING
tenable at University College. Salary £400 a year. Applications (12 copies) must be received not later than first post on 1st Feb., 1921, by the ACADEMIC REGISTRAR, University of London, South Kensington, S.W.7, from whom further particulars may be obtained. L 79

ORDNANCE COLLEGE, WOOLWICH
(Mechanical Engineering Branch).

Applications are Invited for

the POST of DEMONSTRATOR. Salary £230 per annum, rising by £20 to £350.—Applications, stating age, qualifications, etc., should be made, in writing, to: THE COMMANDANT, Ordnance College, Red Barracks, Woolwich. L 231

THE INSTITUTION OF MECHANICAL ENGINEERS.

CUTTING TOOLS RESEARCH COMMITTEE.

Appointment of Research

ASSISTANT.

An extensive programme of Research has been drawn up by the Cutting Tools Research Committee of the Institution, and it is PROPOSED to APPOINT a whole-time RESEARCH ASSISTANT to supervise the experimental work which will be carried out, and to compile reports for the Committee. The salary offered is at the rate of £700 per annum, and travelling expenses, under certain conditions, will be defrayed. Applications for the appointment are invited from persons who possess the necessary scientific and practical qualifications: they should be addressed, not later than 31st December, 1920, to the SECRETARY, INSTITUTION OF MECHANICAL ENGINEERS, Storey's Gate, St. James' Park, Westminster, S.W.1 (marked "Research Assistant"), and should give full details of the Candidates' general and technical education and experience in mechanical engineering and research work. A Candidate should give the names of three engineers of standing who can speak with authority as to his character and technical ability. Further particulars of the appointment can be obtained on application. L 239

Engineer Required as Works

Manager of small works. Must be willing to invest £1000 to £2000. Every investigation. Audited Balance Sheet available.—Address, L 125, Offices of ENGINEERING.

Young Engineer Wanted to

assist with Engineering side of Works Management in Factory in Glasgow. Write giving full particulars of education, training and experience, with copies of references and stating approximately salary required.—Address, L 65, Offices of ENGINEERING.

Engineer Fuel Supervisor for

Factory in Yorkshire REQUIRED to organise and reduce Coal consumption. Must be acquainted with Boilers, Engines, Heat Balances, and theory of Fuel Consumption.—Address, L 70, Offices of ENGINEERING.

Required, thoroughly

Competent and Experienced ENGINEER, about 40 years of age, to take charge of London Office of well known Engineering Valuers and Auctioneers. Commencing salary £500 per annum.—Address, L 214, Offices of ENGINEERING.

Brass Moulder Required to

start and work small castings foundry in connection with engineering firm in Fifeshire. Intelligent man required who understands general work and has ambition. State Wages and Experience.—BOX 664, ROBERTSON & SCOTT, Advertising Agents, Edinburgh. L 209

Wanted in large Marine

Engine Works on North-East Coast, an ASSISTANT, with technical experience for Estimating Dept. Write, stating age, experience and salary required.—Address, L 228, Offices of ENGINEERING.

Wanted, Works Chemist to

take charge of Cement Works Laboratory. Good Organiser, state qualifications and salary.—Address, L 69, Offices of ENGINEERING.

Firm of Specialist Engi-

neering Auctioneers and Valuers REQUIRE the SERVICES of Capable MANAGING ASSISTANT.
He must possess thorough knowledge of General Engineering, Machinery and Plant. Previous experience absolutely essential. Salary about £750 per annum.
Address, L 215, Offices of ENGINEERING.

Producer Gas Plant in B'ham

District.—GOOD MAN REQUIRED as Engineer's Assistant, to take charge of above. Must be well up in Sulphate Recovery and good disciplinarian. Permanency for suitable man. State experience, age and wages required.—Address, L 187, Offices of ENGINEERING.

Wanted by the Cambridge

AND PAUL INSTRUMENT CO., LTD., 45, Grosvenor Place, London, S.W. 1, a YOUNG MAN of good education with electrical knowledge, to train for position on outside selling staff.—Apply, by letter, stating age, technical knowledge, previous experience and salary required. L 189

Rate Fixers Wanted. Must

be men with sound experience in time study for all types of machine and fitting work. Wide experience in actual rate fixing with high class firms essential.—Address, L 242, Offices of ENGINEERING.

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AGE.—22 to 30 years.
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SALARY.—Commencing at Rs. 450 to Rs. 700, according to age and qualifications, rising in accordance with the Companies' Rules.
For the Assistant Engineer for Construction Rs. 640 per calendar month with usual allowances.
Selected candidates will only be finally appointed subject to their being a strict medical examination by the Consulting Physician to the Company concerned.
Applicants must give a full record of their career in chronological order, with dates, giving details of their general and technical education, training and subsequent experience, with copies only of any testimonials, certificates, etc., which they may have in their possession. Details of service with H.M. Forces should be given.
Full particulars, stating age, whether married or single, etc., as set out above, should be sent to Messrs. RENDEL, PALMER & TRITTON, 19/14, Dartmouth Street, Westminster, S.W. 1. L 216

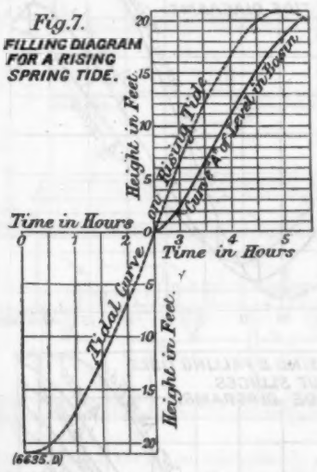
TIDAL POWER DEVELOPMENT.

By Professor A. H. GIBSON.

(*Concluded from page* 780).

SCHEME I.—TURBINES OPERATING ON A FALLING TIDE ONLY, WITH A CONSTANT RATE OF FALL IN THE BASIN.

On the rising tide the basin is filled through sluices whose effective area is taken as 3,500 sq. ft., or 1/8,000 of that of the basin. Assuming the basin to empty down to half-tide level, the level at any instant during the period of filling, may be obtained by considering this process as taking place in a series of stages during each of which the head producing in-flow may be taken as sensibly equal to the mean during the period. Taking the first half-hour after the commencement of the filling period on a spring tide, for example, if the difference of level at the end of this first stage be assumed to be, say, 4 ft., the mean difference will be 2 ft., and the mean rate of influx $\sqrt{2gh} = 11{\cdot}3$ ft. per second. The rise in level in the basin during this first half-hour will then be $\frac{11{\cdot}3 \times 60 \times 30}{8{,}000} = 2{\cdot}55$ ft. The rise in level outside the basin during this period as



obtained from the tidal curve of Fig. 7 is 6·5 ft., so that the difference of level at the end of the period is 3·95 ft., or sensibly as assumed. Proceeding in this way by a process of trial and error, the curve A of Fig. 7 is obtained. This shows that the difference of level at high tide is 2·4 ft. If the sluices be left open, the levels inside and outside the basin equalise 25 minutes after high tide, the common level then being 0·6 ft. below high tide. or 20·4 ft. above mean tide level.

If the basin be emptied down to mean tide level (as in B C, Fig. 8), the volume of water passing the turbines per spring tide $= 20{\cdot}4 \times (5{,}280)^2$ c.f. If the rate of fall is constant and the initial and final heads each 21 ft., the maximum head, obtained by scaling off the diagram, is 25 ft., and the mean head 22·8 ft., so that the output from the turbines

$$= \frac{64 \times 20{\cdot}4 \times (5{,}280)^2 \times 22{\cdot}8 \times 0{\cdot}75}{33{,}000 \times 60} = 315{,}000 \text{ H.P. hours.}$$

The working period occupies 3·7 hours, so that the mean ate of output will be

$$\frac{315{,}000}{3{\cdot}7} = 85{,}000 \text{ H.P.}$$

Similarly, on a neap tide, assuming operation down to half-tide level with an initial and final working head of 8 ft., the mean head becomes 8·76 ft., the maximum head 9·8 ft., and the volume of water passing the turbines $= 7{\cdot}6 \times (5{,}280)^2$ *c.f.*

The output from the turbines

$$= \frac{64 \times 7{\cdot}6 \times (5{,}280)^2 \times 8{\cdot}76 \times 0{\cdot}75}{33{,}000 \times 60} = 45{,}000 \text{ H.P. hours.}$$

The working period occupies 3·3 hours, so that the mean rate of output is 13,650 h.p.

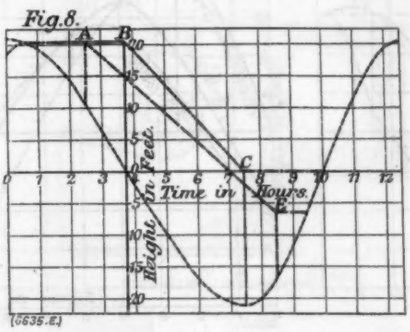
The turbines which, at spring tide, would develop 85,000 h.p. under a mean head of 22·8 ft., would at neap tides, under a mean head of 8·76 ft., develop $85{,}000 \times \left(\frac{8{\cdot}76}{22{\cdot}8}\right)^{\frac{3}{2}} = 20{,}200$ h.p., so that only 67 per cent. of the turbines would be in operation at neap tides.

Adopting these working heads and periods, and assuming a 50 per cent. loss in that portion of the output utilised for pumping in connection with the storage system, the values of K and q become 0·525 and 0·28 respectively, so that

$$P_n = 0{\cdot}525\ P_s \left\{\frac{100-50}{100-14}\right\}$$
$$= 0{\cdot}305\ P_s$$
$$= 0{\cdot}305 \times 315{,}000 \text{ H.P. hours per tide.}$$
$$= 96{,}000 \text{ H.P. hours per tide.}$$

This is equivalent to a continuous output of $\frac{96{,}000}{12{\cdot}5} = 7{,}680$ brake horse-power, or to an output of three times this, or 23,040 brake horse power for an 8-hour working day.

In this scheme of operations the range of working heads is from 25 ft. to 8 ft., and the difficulty of ensuring reasonable efficiencies at constant speed over this range would be great. By reducing the working head at spring tides, this inequality may be reduced, and by arranging the working period so as to extend beyond low tide as indicated in



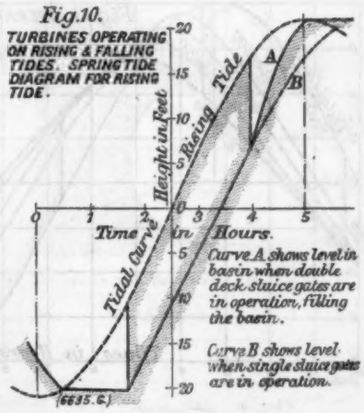


Fig.10.
TURBINES OPERATING ON RISING & FALLING TIDES. SPRING TIDE DIAGRAM FOR RISING TIDE.
Rising Tide
Height in Feet
A
B
Time in Hours.
Tidal Curve
Curve A shows level in basin when double deck sluice gates are in operation, filling the basin.
Curve B shows level when single sluice gates are in operation.
(6635.C)

Fig. 8 (line A E) a greater output may be obtained, while the storage problem is also improved.

Thus taking a constant rate of fall, and extending the working period over 6 hours at spring tides, with an initial head of 10 ft. and a final head of 10 ft., the mean head becomes 17·6 ft. and the maximum head 21 ft.

The fall in level during the working period is now $20{\cdot}4 + 6{\cdot}5 = 26{\cdot}9$ ft., and the output per spring tide is

$$\frac{64 \times 26{\cdot}9 \times (5{,}280)^2 \times 17{\cdot}6 \times 0{\cdot}75}{33{,}000 \times 60} = 320{,}000 \text{ H.P. hours.}$$

The mean rate of output is $320{,}000 \div 6 = 53{,}333$ h.p. Evidently the necessary turbine capacity is appreciably less than in the preceding case.

If the operation at neap tides be unaltered, since turbines which are capable of developing 53,333 h.p. under a mean head of 17·6 ft., will develop $53{,}333 \times \left(\frac{8{\cdot}76}{17{\cdot}6}\right)^{\frac{3}{2}} = 18{,}650$ h.p. at neap tides under the mean head of 8·76 ft., 74 per cent. of the turbines would be in operation at neap tides.

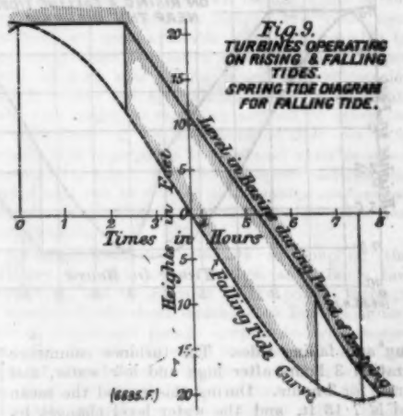
On the same assumptions as before

$$P_n = 0{\cdot}520\ P_s \left\{\frac{100-50}{100-18{\cdot}8}\right\} = 0{\cdot}32\ P_s$$
$$= 102{,}400 \text{ H.P. hours per tide.}$$

equivalent to a continuous output of 8,200 brake horse-power.

Detailed investigation is necessary to determine the most economical development in any particular case. In the case in question, by limiting the turbine capacity to that necessary to absorb the energy available at neap tides, the cost of the turbines, and of the dam in many cases, will be reduced to 74 per cent. of its original value. At higher tides some energy would be wasted, the maximum amount being 26 per cent. of the energy of the highest spring tide. The output at spring tides would now be 237,000 h.p.-hours, and the continuous 24-hour output, making the usual allowances for loss in storage would be approximately 7,000 brake horse-power, or only 15 per cent. less than with the original primary installation.

The necessary size and cost of the pumping plant is also reduced appreciably. In the original installation the maximum output of the primary turbines is 69,500 brake horse-power under the maximum head of 21 ft. and with a continuous supply of 8,200 h.p. into the distribution system,



the surplus, to be absorbed by the pumping installation, has a maximum value of 61,300 h.p. With the reduced primary installation the maximum output becomes 51,500 h.p. and with a continuous supply of 7,000 brake horse-power into the distribution system, the surplus becomes 44,500 h.p. The necessary capacity of the pumping installation is thus reduced by 27 per cent.

SCHEME II.—TURBINES OPERATING ON BOTH RISING AND FALLING TIDES, WITH CONSTANT RATES OF RISE AND FALL IN THE BASIN.

Here it is assumed that the turbines operate on a falling tide to within 1 hour of low water; that operation commences when the initial head is 10 ft. at spring tides and 6·5 ft. at neap tides, and that the rate of fall in the basin is maintained constant so as to give the same head at the instant of closing down. One hour before low water the sluice gates are opened, and the basin empties itself during this hour and the succeeding half-hour. On a rising tide the turbines operate under the same heads to within one hour of high water, the basins being filled through the sluices during this hour and the succeeding quarter hour. At neap tides the turbines are operated to within one-half hour of high and low tides.

The levels in the basin during the periods of emptying and filling have been calculated as previously, and are shown in the curves of Figs. 9 and 10. Here it has been assumed that a double bank of sluices are available for use on a rising spring tide, in which case the basins attain the same level 10 minutes after high tide, this level being 0·2 ft. below high-water level. Only one set of sluices will be available on the falling tide, and here the levels are identical 25 minutes after low tide, the rise of level from low tide at this instant being 0·7 ft.

Spring Tide—Falling Tide (7½ *hours*).—Here the turbines commence operating 2½ hours after high tide and operate for 4½ hours. The maximum head

is 11·9 ft. and the mean head is 11·2 ft. The sea level at 1 hour before low tide is 2·2 ft. above low water level, so that during the working period the level falls

$$42 - 10 - 2.2 - 0.2 = 29.6 \text{ ft.}$$

The output per falling tide

$$= \frac{64 \times (5280)^2 \times 29.6 \times 11.2 \times 0.75}{33000 \times 60} = 224000 \text{ h.p. hours.}$$

The mean horse-power generated during this period is 52,800 h.p.

Rising Tide (5 hours).—The turbines commence working 1½ hours after low tide, and operate for 2½ hours. The maximum head is 11·3 ft. and the mean head 10·8 ft. The sea level at 1 hour before high tide is 4·2 ft. below high water level, so that during the working period the level rises 42 — 10 — 4·2 — 0·7 = 27·1 ft.

The output per rising tide = 19,800 h.p. hours.

The mean horse power during this period = 88,000 h.p.

At Neap Tides.—(Fig. 11), the duration of the operation and the output are the same on both rising and falling tides. The turbines commence operation 3 hours after high and low water, and operate for 3 hours. During this period the mean head is 7·15 ft. and the water level changes by 16 — 6·5 — 0·6 = 8·9 ft.

The output per falling and rising tide = 43,200 h.p. hours.

The mean horse-power generated = 14,400 h.p.

Making the usual allowance for losses in pumping and storage, the mean output per complete tide available over a lunar cycle now becomes 165,000 h.p. hours (K = 0·586, q = 0·5), equivalent to a continuous output of 13,150 brake horse-power.

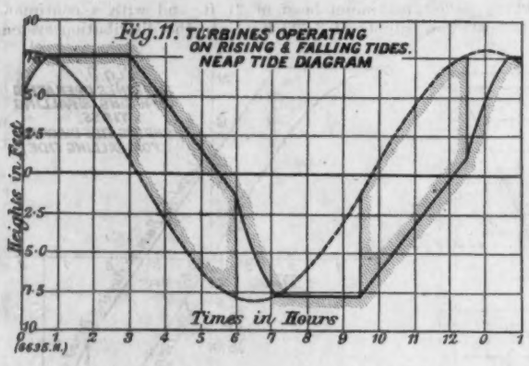
Owing to the rapidity with which the tide rises at springs, the turbine capacity necessary to absorb the whole output is 61 per cent. greater than that necessary to absorb the whole output on a falling tide, allowance being made for the difference of working heads. In order to reduce the necessary capacity of the primary installation this may be cut down to that required to deal with the energy available on a falling tide. The output on a rising tide will then be reduced to 198,000 ÷ 1·61 = 123,000 h.p. hours, and the continuous 24-hour power available over a lunar cycle, becomes 11,000 brake horse-power.

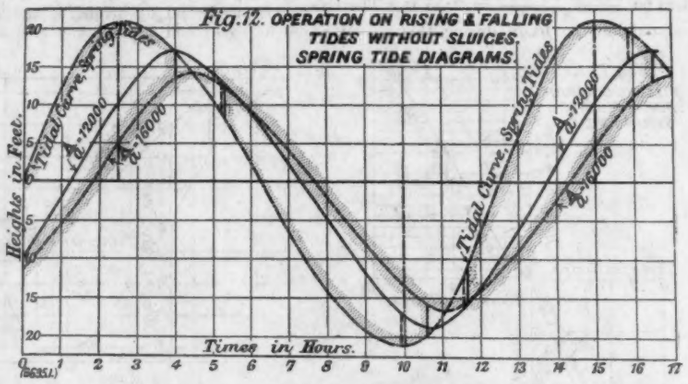
Under these conditions, the turbines which at spring tides develop 52,800 h.p. under 11·2 ft. head, would develop $52{,}800 \times \left(\frac{7{\cdot}15}{11{\cdot}2}\right)^{\frac{3}{2}} = 26{,}900$ h.p. under the mean head of 7·15 ft. available at neap tides, so that 54 per cent. of the turbines would be in operation at neap tides.

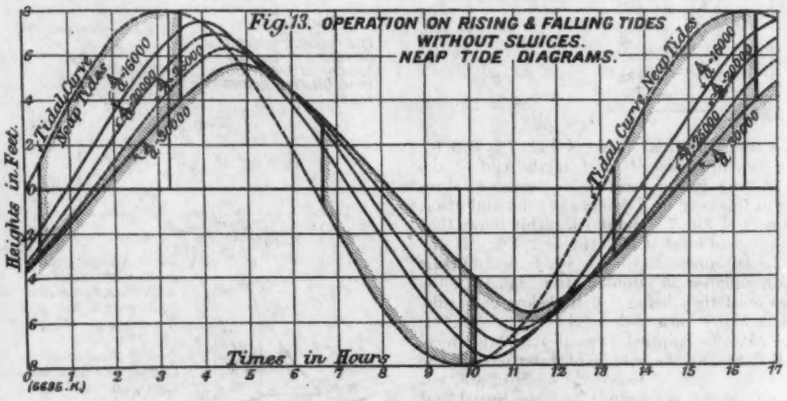
By adopting a working head of 15 ft. at the beginning and end of operation on a spring tide, and by absorbing only part of the energy of the rising tide as before, the continuous 24-hour power becomes 13,000 brake horse-power. The turbines now develop 75,500 h.p. at spring tides, under a mean head of 16 ft., and would develop 22,500 h.p. under the mean head available at neap tides, so that the necessary turbine capacity would be 16 per cent. less than in the former scheme and 64 per cent of the turbines would be in operation at neap tides. Evidently this is a more efficient scheme than that involving a lower working head at spring tides. The most efficient combination of working heads and working periods can only be determined by detailed examination for each particular case, due consideration being paid to the fact that the higher working heads at spring tides involve a bigger range of working head, and in general a lower overall turbine efficiency.

SCHEME III.—OPERATION ON RISING AND FALLING TIDES, THE TURBINES OPERATING UNDER THE NATURAL DIFFERENCE OF HEAD EXISTING AT ANY GIVEN INSTANT.

Let a be the effective area of the turbines considered as a series of orifices, so that under a working head x the volume discharged per second is $a\sqrt{2gx}$. c.f. Let H and h be the heights, above mean sea level, of the water on the sea and basin sides of the dam, at a time t hours after the instant of mean tide. Then if v be the velocity of efflux at this instant, $v = \sqrt{2g(H - h)}$. f.s., and the rate of rise and fall of the surface of the basin $\left(\frac{dh}{dt}\right)$, is given by







$$\frac{dh}{dt} = \frac{a}{A}\sqrt{2g(H - h)}.$$

Given the form of the tidal curve and the value of A ÷ a, the solution of this equation gives the value of h, or the level in the basin at any instant. The curve of levels in the basin is a cyclical curve, having the same period as that of the tidal level, but with a smaller amplitude and a different phase. The amplitude and lag, depend on the ratio A ÷ a. When this ratio is large, the fluctuation of level in the basin is small, and though the working head is large, the power developed is small. When the ratio is small, the fluctuation of level in the basin is large, but the working head is small, and the power developed is small. The maximum output is obtained with some definite value of the ratio, which can only be determined by investigation of each particular case.

To construct the curve of basin levels, a value of A ÷ a and a starting point on the line of mean tidal height are assumed. Sketching in a probable curve of basin levels, the mean difference of level over a period of, say, 1 hour from the starting point is scaled off, and the mean rate of rise in the basin during this period, and therefore the height at the end of the period is calculated. If this does not agree with the corresponding height on the assumed curve, a second trial is to be made, until the two points coincide. Starting now from this point, a second period of 1 hour is taken and so on until the complete cycle has been covered. If the starting point has been correctly chosen, the two curves will intersect at similar points on successive cycles. If they do not, another starting point must be chosen, and the process repeated. A little practice enables the construction to be carried out fairly rapidly. It should be noted, as assisting in the work, that the two curves always cross at a point on the crest of the basin curve, since here the working head is zero, and the rate of rise or fall in the basin is consequently also zero.

An investigation of the case in question shows that maximum output is obtained when A ÷ a is approximately 16,000 at spring tides, and 30,000 at neap tides. A fairly large variation on either side of the best value, does not, however, affect the output greatly, and since an increase in the ratio means a higher working head and hence smaller turbines for a given output, it is advisable to make the ratio somewhat greater than that corresponding to maximum output.

The basin curves have been drawn for spring tides, for A ÷ a = 16,000 and 12,000, and for neap tides for A ÷ a = 16,000, 20,000, 25,000 and 30,000, and are shown in Figs. 12 and 13. The output in horse-power hours may readily be obtained from these diagrams, since the volume of water entering or leaving the basin in any period of, say, 1 hour, is given by the difference of level in the basin at the beginning and end of the period, while the head under which this volume is utilised, is given by the mean intercept between the tidal curve and the basin curve.

The essential figures for the case in question are as follows :—

Spring Tide—Falling Tide (A ÷ a = 16,000).—Period of operation = 6·5 hours. Maximum head = 12·3 ft. Mean head on time base = 8·7 ft. Output = 195,000 h.p. hours.

If the period during which the head is less than 4 ft. be neglected, these figures become : Period of operation = 5·3 hours. Maximum head =

12·3 ft. Mean head = 9·6 ft. Output = 181,000 h.p. hours.

Rising Tide.—Neglecting the period during which the head is less than 4 ft., the period of operation = 4·9 hours; the maximum head = 19 ft.; and the mean head = 13·1 ft. The output = 252,000 h.p. hours.

Neap Tide. $A \div a = 30{,}000$. Fig. 13.—Since the curves for the rising and falling tides are similar at neap tides, the working period and output are the same for both tides. Neglecting the period during which the head is less than 4 ft., the period of operation becomes 3·4 hours; the maximum head, 6 ft.; the mean head, 4·9 ft.; and the output during each of the tides 23,500 h.p. hours.

Combining these results for spring and neap tides gives: $K = 0{\cdot}47$; $q = 0{\cdot}68$; and, with the usual allowance for losses in storage, a continuous 24-hour output of 12,400 brake horse-power.

For comparison, the essential results of the foregoing investigation are tabulated below.

Advantages and Disadvantages of Different Schemes.—The scheme involving operation on a falling tide only has the disadvantage that the output is only about two-thirds of the output theoretically possible with double-way operation. On the other hand, the output per unit of turbine capacity is sensibly the same, while it enables a much more efficient type of turbine setting to be used, and enables the number of sluice gates to be halved. It has the further advantage, where applied to a navigable river that the depth of water in the basin never falls below mean tide level or thereabouts, so that navigation above the basin is improved. The scheme is essentially more simple than any one involving double-way operation, and the balance of advantages would appear to be heavily in its favour.

Double-way operation under natural head has the disadvantage that the variation in working head is normally very great, while if the conditions be modified so as to reduce this variation, the power developed falls off seriously.

General Arrangement of Turbines.—In view of the large number of turbines necessary, and of the great volume of water to be handled, the only feasible arrangement, in a large installation, consists of a long dam, which may require to be curved, or to be carried diagonally across the estuary in order to provide sufficient room for the turbines and sufficient waterway for the necessary sluices. A simple type of setting which has been suggested is shown in Fig. 14, and a second type, intended to reduce the necessary length of dam and the number of sluices by installing the turbines in a double bank, is shown in Fig. 15. Owing to the fact that the modern low-speed turbine has of necessity a high velocity of flow through its runner, often amounting to as much as $0{\cdot}75\sqrt{2gh}$, it is necessary for high efficiency, to form the discharge passages with easy curves and gradually increasing sections, so as to reduce the loss of energy at discharge to a minimum, and so as to reduce the velocity of ultimate discharge to something in the neighbourhood of 4 f.s. For example, with a mean working head of 13 ft. (4 m.) the velocity of discharge from the runner, taking this to be only $0{\cdot}5\sqrt{2gh}$ would be equivalent to a head of 2·5 ft., and the maximum possible overall efficiency of the turbine, assuming a hydraulic efficiency of 85 per cent. in the turbine itself would only be

$$\cdot 85\left\{\frac{10 - 2{\cdot}5}{10}\right\} = \cdot 64$$

if the whole of this discharge energy were rejected, as would be the case with either of the settings illustrated. With double banked turbines, the difficulty of obtaining a sufficient waterway area in the face of the dam, to ensure even such velocities as these is almost insuperable, and would appear definitely to preclude this type of setting.

The only really efficient type is indicated in Fig. 16. Adopting this, a turbine capable of developing 3,000 brake horse-power under a head of 13 ft. would require a spacing of about 52 ft., giving an output, under this head, of approximately 60 brake horse-power per foot run of the dam. With smaller turbines the output per foot run of dam would be smaller, amounting to about 50 brake horse-power per foot run for turbines of 2,000 brake horse-power capacity.

Thus in Scheme I, 17 turbines, each of 2,000 brake horse-power capacity would be required, and these would require a dam at least 680 ft. long.

Owing to the relatively large variations in working head in any simple scheme, the question of the most suitable type of generating machinery is one of some difficulty.

Under the extreme variations of head occurring in any such scheme, the efficiency of any constant-speed turbine falls off somewhat rapidly, especially at the lower heads, although recent developments of such turbines have shown results which would have appeared impossible only a few years ago. Turbines are now available which are capable of operating under a variation of head equal to 50 per cent. on each side of the mean, with efficiencies which do not fall appreciably below 70 per cent. over this range, so that this method of operation is quite feasible. It is understood that one well-known firm is prepared to construct variable-speed turbines coupled to constant-speed alternators, and if this can be done without undue mechanical complication and cost, it will probably prove the best solution.

Another possibility consists in coupling the primary turbines to alternators, at a fairly low frequency, and to transmit all the power, through a comparatively short transmission line, to motor-driven centrifugal pumps coupled to synchronous motors. In order to avoid the cost and complication of transformers, the limit of voltage might be that for which the machines can be conveniently wound, *i.e.*, about 10,000 volts. Under these conditions the speed of the primary turbines would be allowed to vary with the working head and the speed of the pumps would vary in the same ratio. In this case multi-stage pumps would be necessary, with provision for adjusting the number of stages in use according to the speed of the primary turbines. This method, involving the storage of all the output of the primary turbines, however, involves a relatively low overall efficiency.

The difficulties of speed variation and electrical regulation could largely be overcome by the use of direct-current generators, which would enable the turbines to be operated always at the speed corresponding to the available head, and under conditions of high hydraulic efficiency, and in view of the possibilities of the Thury scheme of high-pressure direct-current generation and transmission this method must be considered as offering a possible solution.

Another possibility consists in coupling the primary turbines directly to centrifugal pumps discharging into the storage reservoir through one or more conduits or pipe lines. The practical feasibilities of this depends on the topographical features of the site. Where the storage reservoir is not in very close proximity to the dam, and where the head is large, the cost of the necessary conduits would in general be excessive. Moreover, the difficulty of arranging the design of the dam so as to include these, would be great. It is probable indeed that this latter factor would preclude the use of this otherwise simple method in any installation having a long dam and a large number of primary turbines, though it might offer the best solution in a small installation.

For any given scheme, it is essential to give full consideration to all the possible mechanical and electrical expedients for developing the power, and to compare these from the view of simplicity, overall efficiency, first cost and cost of operation and maintenance.

Fig. 14.

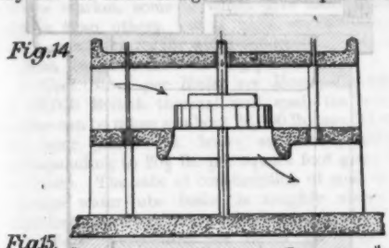
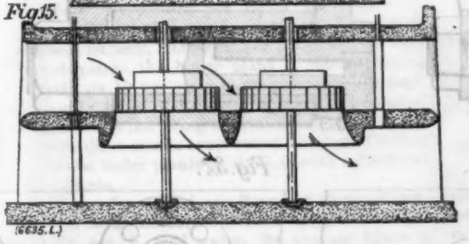


Fig. 15.



(6635.L.)

Fig. 16.

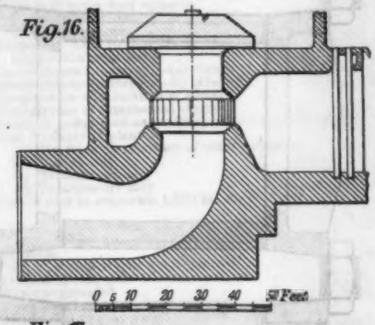
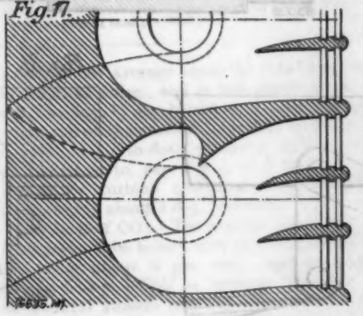


Fig. 17.



(6635.M.)

TABLE SHOWING THE COMPARATIVE RESULTS OF WORKING UNDER THE SCHEMES I, II AND III.

Scheme.	Method of Operation.		Output, Continuous 24-Hour assuming 50 per Cent. Losses in Pumping and Storage.	Working Period per 25 Hours.		Working Heads.				Capacity (under a Head of 13 ft.) of Primary Turbines required for the Scheme.
						Springs.		Neaps.		
				Springs.	Neaps.	Max.	Min.	Max.	Min.	
I	Falling tide only—with constant rate of fall in basin	(*a*)	7,680	7·4	6·6	25·0	21·0	9·8	8·0	36,700
		(*b*)	8,400	12·0	6·6	22·5	8·0	9·8	8·0	33,600
II	Rising and falling tides—with constant rates of rise and fall in basin									
	All energy absorbed ..	(*a*)	13,150	13·0	12·0	11·9	10·0	7·8	6·5	116,000
	Only part of energy absorbed on a rising spring tide	(*b*)	11,000	13·0	12·0	11·9	10·0	7·8	6·5	68,000
III	Operation on rising and falling tides under natural head		12,400	20·4	13·6	19·0	4·0	6·0	4·0	54,000

DEFECTS IN MOTOR VEHICLES AND THEIR REMEDY.

By F. Strickland.

(*Continued from page 464.*)

Spring Shackles and Shackle Pins.

A detail which needed a very large number of spares in certain makes of vehicle was spring shackles and shackle pins. Although these are only small parts of no great cost individually there are several on each vehicle, and when a large fleet of vehicles is run the total cost of renewals may be considerable. As in the case of many other parts the defects of spring shackles and pins fall under two heads. First undue wear of the parts which are intended to be wearing surfaces, and second wear of what are intended to be fixed parts. The first is a matter of bearing surface and lubrication, but the latter is the more serious and depends on the principle of design. In this connection it should be remarked that it is desirable that the shackles should have good lateral rigidity, as with the usual systems of springing they control the lateral position of the vehicle, and if there is lack of rigidity there will be unpleasant swinging at any speed. As the whole of the centrifugal force of the weight above the springs is taken by the latter when the vehicle goes round a corner the lateral load on the shackles is considerable.

It is probably for this reason that the shackles, are usually made relatively short. It is obvious that the longer the shackles the smaller the arc through which they oscillate, and it would appear at first sight that they should therefore be made longer than they usually are so as to reduce this arc as much as possible. The increase in length, however, increases the bending moment on the shackle and also the pressure on the anchorage of the pins and on the bearings.

Fig. 26 shows the simplest form of spring shackle. This was used on one make of vehicle and proved the reverse of durable, but has the merit of being very cheap to make and therefore to renew. It will be seen that it fails completely to fulfil the condition of lateral rigidity. The result therefore is that the pins rapidly get loose in the shackles and the latter then cut into the pins, while the holes wear oval. The shackles as well as the pins have then to be scrapped.

It is possible that this type of shackle could be made satisfactory if constructed as shown in Fig. 27, as considerable lateral rigidity could be obtained while all parts would still be cheap to make.

The more usual form of shackle is shown in Fig. 28. The difficulty here is that each pin has to be a push fit in the eyes, and unless this is very accurate the pin gets "alive" in the eye and rapidly wears the hole oval, in which case both shackle and pin must be scrapped.

The satisfactory working of this type of shackle depends very largely on the proportions and workmanship. If the size of the parts is ample and the work good the result may be very durable, but if, to save weight, the parts are small there is considerable wear. The pins should in all cases be case-hardened and ground.

The pins usually run in bronze bushes, and this works very well if they are properly lubricated. It is, however, difficult to get lubrication properly attended to. It is usual to have a small grease cup at the end of the shackle pin with a grease-way along the pin, as shown in Fig. 28. These grease cups are very apt to get neglected. Some lorries have oil cups in place of grease, and this appears better.

If practicable it would be much better to have bearings which need no lubrication. It hardly seems practicable to use ball or roller bearings, but oilless bushes are being used in the United States of America, and if satisfactory will be a great advantage.

Front Spring Hangers.

A point affecting the safety of the light cars is the arrangement of the spring hanger of the front spring. With the usual arrangement of front springs the axle is only attached to the frame by the front part of the spring. A considerable number of springs broke, and if the fracture is between the axle and the front dumb iron there is nothing to hold the axle except the back spring shackle.

In the earlier days of motor cars the shackle was in tension, being hung from a hanger as Fig. 29, following carriage practice. Later, however, the shackle was generally put in compression in Fig. 30, as a bracket is saved and the appearance is neater.

In case of the front spring breaking in front of the axle, Fig. 29 is in stable equilibrium, Fig. 30 is not. Further, in Fig. 29, the motion backwards is limited, while in Fig. 30 the link may often swing back to the position shown in dotted lines. In the latter case the motion of the axle is considerable, and the car frequently gets quite out of control.

The result of this, in France, was a number of very serious accidents owing to cars running off the road at speed. In order to avoid these a short length of belting was fixed under the spring at the spring seat and taken to the front dumb iron so as to prevent the axle going back in case of the spring breaking. This belting will be found on many of the cars which the Government is disposing of. While this belting was the usual method of securing the axle in the service there are neater ways of doing so.

Figs. 31 and 32 show two methods which were tried and found effective.

In Fig. 31, two short lengths of angle iron were bolted to the shackle and made stops so that in case of the spring breaking they limited the motion of the shackle. This proved effective and easily adapted to the spring shackles of some cars. It was very cheap and easy to apply, only needing two bits of angle about 2 in. long, and one bolt for each front spring shackle. Fig 32 shows another arrangement, which was also very effective and not expensive, consisting of a plate about ¼ in. thick bolted to the frame, and having a slot allowing the necessary motion to the shackle, but preventing motion beyond this.

It is obvious that either of these principles could be worked into the design of a new vehicle without any material increase in weight or expense. It seems very desirable that some arrangement to limit the motion of the spring in case of breakage in view of the very serious result of a car getting out of control.

(*To be continued.*)

Fig. 26.

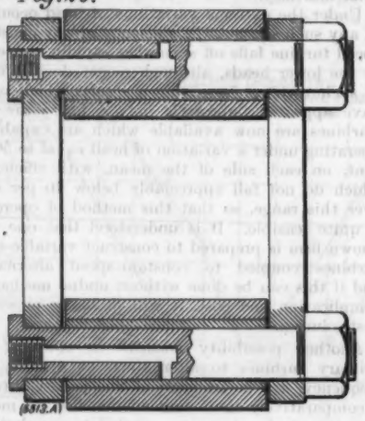


Fig. 27.

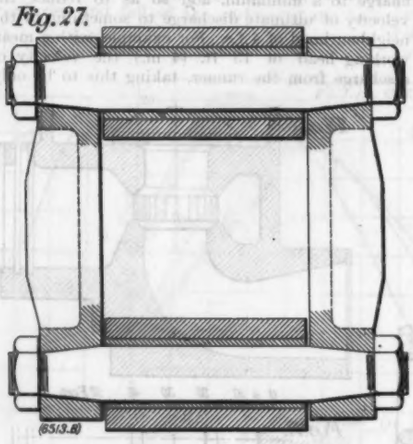


Fig. 28.

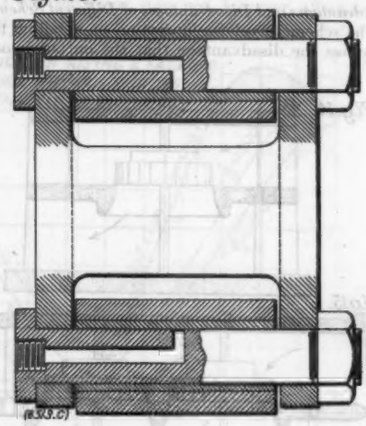


Fig. 29.

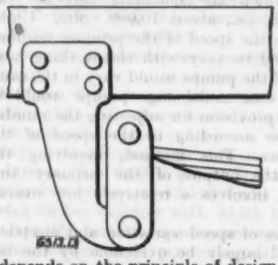


Fig. 30.

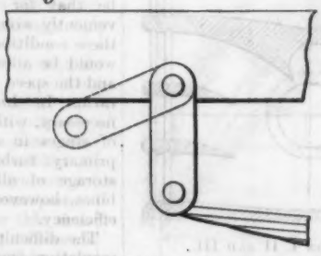


Fig. 31.

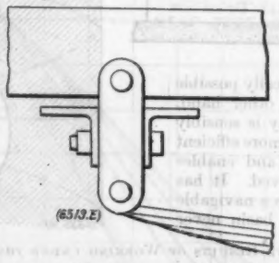
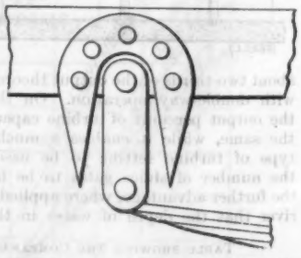


Fig. 32.



Coastal Motor Boats.—The important service performed by the coastal motor boats in the war, when they proved most successful against the German submarines and crowned their activities by raiding Kronstadt Harbour and sinking a number of Bolshevik battleships, has resulted in such boats now being continued as a regular arm of the new Navy. The first to be completed of the Admiralty's post-war programme, successfully passed her official trials last week, when a mean speed of 37 knots was obtained after a series of trials over the official Admiralty course, and the boat was handed over by her builders, Messrs. John I. Thornycroft and Co., Limited. The new boat is a 55 ft. model designed for carrying torpedoes, depth charges, Lewis guns, &c.

EXACT DATA ON THE PERFORMANCE OF STEAM BOILER PLANTS.

No. IV.—*Average Figures for the Performance of Some Different Types of Steam Boilers.*

By DAVID BROWNLIE, B.Sc., Hons. (Lond.), F.C.S., A.I.Mech.E.

(*Concluded from page* 761.)

WATER-TUBE BOILER PLANTS.

THE following figures are calculated for standard-sized water-tube boilers with a rated evaporation of 20,000 lb. water per hour each, say about 5,250 sq. ft. of heating surface with grates 14 ft. by 5 ft., taking as a typical plant five or six such boilers, four working at a time. The boilers are fired by mechanical stokers, as very few tubular boilers are hand-fired, except small boilers of, say, 10,000 lb. hourly evaporative capacity. When fitted with economisers each boiler has its own separate set of economisers, the present standard practice. The water-tube boiler plant may be said to be the typical power-station plant, and is also installed in many factories where high steam pressure is required. There are, of course, a considerable number of different makes of water-tube boiler on the market, some of which give more efficient results than others, but I have endeavoured to give average figures for water-tube boilers generally.

With regard to the following points :—

1. *Coal Burnt per Boiler per Hour.*—Calculated as 12,000 British thermal unit coal, the average figures can be taken as about 28,000 lb. (say, 1¼ tons) per hour (20,000 lb. boiler as already stated), corresponding to 20½ lb. per square foot grate area per hour. The rate of consumption of coal on the average water-tube boiler is roughly about the same irrespective of the results being obtained.

2. *Water Evaporated per Boiler per Hour.*—In average plants the rated evaporation is being obtained, namely, 20,000 lb. per hour, and on very efficient plants the boiler plant is often working regularly on 10 per cent. to 20 per cent. overload. It is only on very bad plants that the nominal evaporation is not being obtained, and there is not the same difference in evaporation between different water-tube boiler plants as there is with cylindrical boiler plants.

3. *Water Evaporated per Pound of Coal.*—Calculated, as usual, on 12,000 British thermal unit coal and 110 deg. F. feed water, the average figure is 7 lb. of water per pound of coal, corresponding to, say, 8 lb. of water from and at 212 deg. F. On bad plants the corresponding figures are 6½ lb. and 7½ lb. Here, again, the average figures usually taken, such as 9 lb. to 10 lb. of water from and at 212 deg. F., are quite erroneous, and only apply to a few plants.

4. *Draught.*—For the average water-tube boiler plant the standard practice is to use mechanical induced or forced draught, or a combination of both, with a short steel chimney, say, 60 ft. to 100 ft. high. In such cases the draught in the fan inlet is only about 0·5 in. water gauge, very much less than induced draught for cylindrical boilers. Roughly, the same figures apply to a most modern plant, whilst on a bad plant the draught is often greater. A number of water-tube boiler plants are worked on chimney draught only, especially small plants, but the draught obtained in practice is not much less, as a comparatively high chimney is then generally used. It may be remarked that the standard short steel chimney and mechanical draught used with water-tube boilers is apt to give much trouble with grit and dirt discharged from the chimney.

5. *Temperature of Flue Gases.*—In the average water-tube boiler plant the gases leave the boiler at about 470 deg. F., corresponding to about 325 deg. F. in the chimney base, which is very much less than in the case of cylindrical boilers. In the case of a bad plant the gases may go up to, say, 575 deg. F., leaving the boiler, but this is exceptional, and in very good plants the temperature may be only 450 deg. F., leaving the boiler and 300 deg. F. leaving the plant.

6. *Quality of Feed Water.*—As is well known, scale is much more serious for water-tube boilers than for cylindrical boilers, and there is considerable amount of trouble with water-tube boilers due to scale. In average cases the total hardness can be taken as 8 deg., and in bad plants ordinary feed water at, say, 11 deg. hardness, is used regularly. On a plant run on the most efficient lines the practice is to have an up-to-date softening plant which softens the water to, say, 5 deg. to 6 deg., and to use engine or turbine condensate, so that the mixture has only about 3 deg. hardness.

7. *Percentage of* CO_2.—The average percentage of CO_2 from water-tube boilers with mechanical stokers is low, being about 6 per cent., and less than cylindrical boilers. This is because the fires on the mechanical stokers tend to burn thin at the back, so that nothing but ash is present, and, consequently, a large excess of air passes. Even in the worst plants the figure for CO_2 is practically as good as the average. On the few plants run on modern lines this result is, however, avoided, and the figure averages about 12½ per cent.

8. *Superheaters.*—The average water-tube boiler installation makes much better use of superheaters than the cylindrical boiler installation, and the average figures for superheat can be taken as, say, 160 deg. F. to 200 deg. F. Even a poor plant is almost invariably fitted with superheaters, as it is the custom for the boiler maker to include superheaters as part of the installation of the boiler. In a very modern plant very high figures are obtained, say, 650 deg. F. final temperature, corresponding to about 250 deg. to 280 deg. superheat.

9. *Economisers.*—Economisers give less saving on a water-tube plant than with cylindrical boilers, because more heat is retained by a water-tube boiler, leaving less to be absorbed by the economiser. Thus, in average cases, the number of tubes in the economiser for a 20,000-lb. boiler is 200, the feed water being heated from 110 deg. F. to, say, 195 deg. F., saving 7·4 per cent. in the coal bill. On a poor plant no economisers are installed, whilst on a most modern plant the saving reaches say 10½ per cent. with a temperature of 225 deg. F. in the feed water leaving the economiser.

10. *Steam or Power used Auxiliary to the Production of Steam.*—It is almost the universal custom, as already stated, to work water-tube boiler plants with mechanical forced or induced draught, and steam jets are not used. The figure for auxiliary steam or power varies from 1·5 per cent. to 2·5 per cent. of the production in all classes of plants.

11. *Efficiency of Plant.*—On an average a water-tube boiler plant is working at, say, 60 per cent. efficiency for the boilers only, and 69 per cent. for the whole plant, including economisers and superheaters and deducting the power used auxiliary to the production of steam. Bad plants may only give a total of about 60 per cent. net working efficiency. These figures, again, are very much less than what is usually supposed. It is a common belief that, generally speaking, a water-tube boiler plant is very much more efficient than a cylindrical boiler plant, and that more or less all water-tube boiler plants are efficient. This idea is entirely wrong. Figures like 80 per cent. to 82½ per cent. net working efficiency with 65 per cent. due to the boiler only and 9 lb. of water from and at 212 deg. F. per lb. of coal are only obtained by a few plants, although, of course, possible on most water-tube plants. As already stated, a cylindrical boiler plant will run on 77½ per cent. to 80 per cent. under good conditions, whilst the average is 60 per cent. It should also be remembered that the wear and tear and cost of upkeep is, on the average, considerably greater than "Lancashire" boilers.

SMALL CYLINDRICAL BOILER INSTALLATIONS.

Generally consisting of one or two small "Lancashire" boilers of some such dimensions as 15 ft. by 5 ft. 6 in., or one or two small "Cornish" boilers of similar dimensions, hand-fired, working without economisers, and with a very small chimney. There are hundreds of such installations scattered about the country in small works, hotels and hydros, various public institutions, &c., with an average coal bill of, say, 10 tons to 20 tons a week.

Such small boiler installations are all worked more or less on the same general lines. The amount

TABLE II.—WATER-TUBE BOILER PLANTS.

	Bad Plant Representing, say, 10 per Cent. of Boiler Plants at Work in Great Britain.	Ordinary Average Plant as being Generally Worked To-day, Representing 85 per Cent. of Plants at Work in Great Britain.	Most Efficient Plant Working under Modern Scientific Supervision or under Test Conditions, Representing only about 5 per Cent. of Plants at Work in Great Britain.
A. WORKING-DAY TEST.			
1. Number of boilers working	4	4	4
2. Grate area (total)	560·0 sq. ft.	560·0 sq. ft.	560·0 sq. ft.
3. Duration of test	12 hours	12 hours	12 hours
4. Price of coal used (per ton delivered)	40*s.*	40*s.*	40*s.*
5. Amount of coal used	139,765 lb.	141,040 lb.	137,275 lb.
6. Analysis of coal—British thermal units	12,000	12,000	12,000
7. Analysis of coal—ash	10·5 per cent.	10·5 per cent.	10·5 per cent.
8. Coal burned per boiler per hour	2,911·7 lb.	2,938·3 lb.	2,859·9 lb.
9. Coal burned per square foot grate area per hour	20·8 lb.	20·9 lb.	20·4 lb.
10. Water evaporated, pounds	808,656 lb.	980,352 lb.	1,081,200 lb.
11. Water evaporated per boiler per hour	18,722·0 lb.	20,611·0 lb.	2,232·5 lb.
12. Water evaporated per square foot grate area per hour	133·7 lb.	147·2 lb.	160·9 lb.
13. Water evaporated per pound of coal	6·43 lb.	7·01 lb.	7·87 lb.
14. Equivalent evaporation from and at 212 deg. F. per pound of coal	7·46 lb.	8·12 lb.	9·11 lb.
15. Equivalent evaporation from and at 212 deg. F. per 1,000,000 British thermal units	621·6 lb.	676·6 lb.	759·2 lb.
16. Temperature of feed-water before economisers	110 deg. F.	110 deg. F.	110 deg. F.
17. Temperature of feed-water after economisers	No economisers	195 deg. F.	225 deg. F.
18. Percentage of coal bill saved by economisers	None	7·4 per cent.	10·4 per cent.
19. Draught in back flues of boilers	0·70 in. W.G.	0·35 in. W.G.	0·30 in. W.G.
20. Draught in chimney base	0·75 in. W.G.	0·50 in. W.G.	0·65 in. W.G.
21. Temperature of flue gases before economisers	575 deg. F.	475 deg. F.	450 deg. F.
22. Number of economiser tubes	None	200	—
23. Temperature of flue gases after economisers	No economisers	325 deg. F.	300 deg. F.
24. Analysis of boiler feed water—			
Degrees permanent	9 deg.	6 deg.	3 deg.
Degrees temporary	2 deg.	2 deg.	0 deg.
25. Percentage CO_2 in flue gases (continuous record on combustion recorder)	5·0 per cent.	6·0 per cent.	12·5 per cent.
26. Steam pressure (average)—(*a*) Gauge	150 lb.	155 lb.	160 lb.
27. Steam pressure (average)—(*b*) Absolute	165 lb.	170 lb.	175 lb.
28. Temperature of saturation of steam	365·9 deg. F.	368·3 deg. F.	370·5 deg. F.
29. Temperature of superheated steam	450·0 deg. F.	530·0 deg. F.	650·0 deg. F.
30. Steam or power used as auxiliary to production of steam	2·5 per cent.	2·0 per cent.	1·5 per cent.
Thermal efficiency of plant—			
31. (*a*) Net working efficiency of plant complete	61·0 per cent.	69·2 per cent.	81·9 per cent.
32. (*b*) Boilers only	59·9 per cent.	60·3 per cent.	65·8 per cent.
33. (*c*) Economisers only	None	4·9 per cent.	7·6 per cent.
34. (*d*) Superheaters only	2·6 per cent.	5·4 per cent.	9·7 per cent.
35. Cost in coal to evaporate 1,000 gallons of water	333·2*d.*	305·3*d.*	272·0*d*
LONG CHECK TEST (ONE WEEK). (Say Two Shifts per 24 Hours.)			
36. Duration	168 hours	168 hours	168 hours
37. Price of coal used (per ton delivered)	40*s.*	40*s.*	40*s.*
38. Amount of coal used	458·2 tons	452·0 tons	467·5 tons
39. Water evaporated	651,740 gallons	703,674 gallons	815,769 gallons
40. Water evaporated per pound of coal	6·35 lb.	6·95 lb.	7·79 lb.
41. Cost in coal to evaporate 1,000 gallons of water	337·4*d.*	306·3*d.*	275·0*d.*
42. Coal bill for 20,000,000 gallons evaporated per annum (say 220 tons of coal per week)	28,120*l.*	25,688 .	22,920 .

Table III.—*Small Cylindrical Boiler Plants.*

	Ordinary Average Plant as Generally being Worked To-day.
A. Working-Day Test.	
1. Number of boilers working	2 "Lancashire"
2. Grate area (total)	40 sq. ft.
3. Duration of test	12 hours
4. Price of coal used (per ton delivered)	40s.
5. Amount of coal used	8,926 lb.
6. Analysis of coal—British thermal units	12,000
7. Analysis of coal—Ash	10·5 per cent.
8. Coal burned per boiler per hour	346·8 lb.
9. Coal burnt per square foot grate area per hour	17·3 lb.
10. Water evaporated, pounds	48,840 lb.
11. Water evaporated per boiler per hour	2,035 lb.
12. Water evaporated per square foot grate area per hour	101·7 lb.
13. Water evaporated per pound of coal	5·86 lb.
14. Equivalent evaporation from and at 212 deg. F. per pound of coal	6·71 lb.
15. Equivalent evaporation from and at 212 deg. F. per 1,000,000 British thermal units	559·2 lb.
16. Temperature of feed-water before economisers	110 deg. F.
17. Temperature of feed-water after economisers	Nil (No economisers).
18. Percentage of coal bill saved by economisers	Nil
19. Draught in back flues of boilers	0·50 in. W.G.
20. Draught in chimney base	0·25 in. W.G.
21. Temperature of flue gases before economisers	590 deg. F.
22. Number of economiser tubes	No economisers
23. Temperature of flue gases after economisers	No economisers (*i.e.*, 590 deg. F.)
24. Analysis of boiler feed water—	
Degrees permanent	9 deg.
Degrees temporary	2 deg.
25. Percentage CO_2 in flue gases (continuous record on combustion recorder)	5 per cent.
26. Steam pressure (average)—(*a*) Gauge	70 lb.
27. Steam pressure (average)—(*b*) Absolute	85 lb.
28. Temperature of saturation of steam	316·1 deg. F.
29. Temperature of superheated steam	No superheat
30. Steam or power used as auxiliary to production of steam	None
Thermal efficiency of plant—	
31. (*a*) Net working efficiency of plant complete	54·1 per cent.
32. (*b*) Boilers only	54·1 per cent.
33. (*c*) Economisers only	Nil
34. (*d*) Superheaters only	Nil
35. Cost in coal to evaporate 1,000 gallons of water	365·2d.
B. Long Check Test (One Week). (Say Two Shifts per 24 Hours.)	
36. Duration	168 hours
37. Price of coal used (per ton delivered)	40s.
38. Amount of coal used	17·5 tons
39. Water evaporated	21,952 gallons
40. Water evaporated per pound of coal	5·60 lb.
41. Cost in coal to evaporate 1,000 gallons of water	382·5d.
42. Coal bill for 20,000,000 gallons evaporated per annum (say, 220 tons of coal per week)	31,886*l.*

Table IV.—*Small Vertical Boiler Plants.*

	Ordinary Average Plant as Generally being Worked To-day.
A. Working-Day Test.	
1. Number of boilers working	1
2. Grate area (total)	—
3. Duration of test	12 hours
4. Price of coal used (per ton delivered)	40s.
5. Amount of coal used	1,353 lb.
6. Analysis of coal—British thermal units	12,000
7. Analysis of coal—Ash	10·5 per cent.
8. Coal burned per boiler per hour	112·75 lb.
9. Coal burnt per square foot grate area per hour	—
10. Water evaporated, pounds	7,103 lb.
11. Water evaporated per boiler per hour	591·9 lb.
12. Water evaporated per square foot grate area per hour	—
13. Water evaporated per pound of coal	5·25 lb.
14. Equivalent evaporation from and at 122 deg. F. per pound of coal	6·01 lb.
15. Equivalent evaporation from and at 212 deg. F. per 1,000,000 British thermal units	500·9 lb.
16. Temperature of feed-water before economisers	110 deg. F.
17. Temperature of feed-water after economisers	Nil (No economisers)
18. Percentage of coal bill saved by economisers	Nil
19. Draught in back flues of boilers	0·25 in. W.G.
20. Draught in chimney base	0·30 in. W.G.
21. Temperature of flue gases before economisers	800 deg. F.
22. Number of economiser tubes	No economisers
23. Temperature of flue gases after economisers	No economisers (*i.e.*, 800 deg. F.)
24. Analysis of boiler feed water—	
Degrees permanent	9 deg.
Degrees temporary	2 deg.
25. Percentage CO_2 in flue gas (continuous record on combustion recorder)	5 per cent.
26. Steam pressure (average)—(*a*) Gauge	70 lb.
27. Steam pressure (average)—(*b*) Absolute	85 lb.
28. Temperature of saturation of steam	316·1 deg. F.
29. Temperature of superheated steam	No superheat
30. Steam or power used as auxiliary to production of steam	None
Thermal efficiency of plant—	
31. (*a*) Net working efficiency of plant complete	48·4 deg. F.
32. (*b*) Boilers only	48·4 deg. F.
33. (*c*) Economisers only	Nil
34. (*d*) Superheaters only	Nil
35. Cost in coal to evaporate 1,000 gallons of water	408·1d.
B. Long Check Test (One Week). (Say Two Shifts per 24 Hours.)	
36. Duration	168 hours
37. Price of coal used (per ton delivered)	40s.
38. Amount of coal used	4·5 tons
39. Water evaporated	5,141 gallons
40. Water evaporated per pound of coal	5·10 lb.
41. Cost in coal to evaporate 1,000 gallons of water	420·0d.
42. Coal bill for 20,000,000 gallons evaporated per annum (say, 220 tons of coal per week)	35,000*l.*

Table V.—*Egg-Ended Boiler Plants.*

	Ordinary Average Plant as Generally being Worked To-day.
A. Working-Day Test.	
1. Number of boilers working	4
2. Grate area (total)	112 sq. ft.
3. Duration of test	12 hours
4. Price of coal used (per ton delivered)	40s.
5. Amount of coal used	30,240 lb.
6. Analysis of coal—British thermal units	12,000
7. Analysis of coal—Ash	10·5 per cent.
8. Coal burned per boiler per hour	630 lb.
9. Coal burnt per square foot grate area per hour	22·5 lb.
10. Water evaporated, pounds	112,800 lb.
11. Water evaporated per boiler per hour	2,350 lb.
12. Water evaporated per square foot grate area per hour	83·9 lb.
13. Water evaporated per pound of coal	3·73 lb.
14. Equivalent evaporation from and at 212 deg. F. per pound of coal	4·26 lb.
15. Equivalent evaporation from and at 212 deg. F. per 1,000,000 British thermal units	355 lb.
16. Temperature of feed-water before economisers	110 deg. F.
17. Temperature of feed-water after economisers	Nil (No economisers)
18. Percentage of coal bill saved by economisers	Nil
19. Draught in back flues of boilers	0·90 in. W.G.
20. Draught in chimney base	1·00 in. W.G.
21. Temperature of flue gases before economisers	850 deg. F.
22. Number of economiser tubes	No economisers
23. Temperature of flue gases after economisers	No economisers (*i.e.*, 850 deg. F.)
24. Analysis of boiler feed-water—	
Degrees permanent	12 deg.
Degrees temporary	5 deg.
25. Percentage CO_2 in flue gas (continuous record on combustion recorder)	3·75 per cent.
26. Steam pressure (average)—(*a*) Gauge	55 lb.
27. Steam pressure (average)—(*b*) Absolute	70 lb.
28. Temperature of saturation of steam	320·9 deg. F.
29. Temperature of superheated steam	No superheaters
30. Steam or power used as auxiliary to production of steam	Nil
Thermal efficiency of plant—	
31. (*a*) Net working efficiency of plant complete	34·3 per cent.
32. (*b*) Boilers only	34·3 per cent.
33. (*c*) Economisers only	Nil
34. (*d*) Superheaters only	Nil
35. Cost in coal to evaporate 1,000 gallons of water	574·4d.
B. Long Check Test (One Week). (Say Two Shifts per 24 Hours.)	
36. Duration	168 hours
37. Price of coal used (per ton delivered)	40s.
38. Amount of coal used	82 tons
39. Water evaporated	67,050 gallons
40. Water evaporated per pound of coal	3·65 lb.
41. Cost in coal to evaporate 1,000 gallons water	587·0d.
42. Coal bill for 20,000,000 gallons evaporated per annum (say, 220 tons of coal per week)	48,918*l.*

of coal burnt can be taken as an average of 17 lb. per square foot grate area per hour with grates 4 ft. by 5 ft., and coal as before, averaging 12,000 British thermal units per pound. As regards evaporation, this can best be estimated from the average figures of an evaporation of, say, 5¾ lb. of water at 110 deg. F. per lb. of coal, corresponding to 6¾ lb. of water from and at 212 deg. F. Thus, on a small "Lancashire" boiler of 15 ft. by 5 ft. 6 in., the figure is about 200 gallons per boiler per hour. The draught is usually about 0·5 in. suction water gauge in the chimney base, the chimney being small, say, averaging 50 ft. to 75 ft., and on such small plants mechanical draught is practically never used. Also, it is not general practice to use steam-jet furnaces on such plants, but if present, the average figure for the steam consumption of the jets will be 5 per cent. to 10 per cent. of the production of the plant, with a corresponding drop in efficiency. The temperature of the flue gases in the chimney base averages about 600 deg. F., and, as before, the average hardness of the water can be taken as 11 deg. total hardness. Economisers and superheaters are practically never installed, but if present, the saving due to these can be calculated as already shown, namely, 11 deg. F. rise in the feed water, corresponding to 1 per cent. saving in the coal bill, and 1 deg. F. rise in the superheat equals 0·05 per cent. saving. The net working efficiency is about 54 per cent., and probably does not vary more than between 50 per cent. to 60 per cent., no matter what attention is given to the plant.

Small Vertical Boilers.

This is a class generally used by builders and contractors, on farms, in engineering works where a small amount of isolated steam is required, and other similar uses. Such boilers have usually

Summary of Results.

	Cylindrical Boiler ("Lancashire" &c.).			Water-Tube Boiler.			Small Cylindrical Boiler Average.	Small Vertical Boiler Average.	Egg-ended Average.
	Average Plant, 85 per Cent.	Good Plant, 5 per Cent.	Bad Plant, 10 per Cent.	Average Plant, 85 per Cent.	Good Plant, 5 per Cent.	Bad Plant, 10 per Cent.			
Coal burnt per boiler per hour lb.	864·7	1,059·8	755·2	2,938·3	2,859·9	2,911·7	346·8	112·75	630·0
Coal burnt per square foot grate area per hour lb.	22·7	27·9	19·8	20·9	20·4	20·8	17·3	—	22·5
Water evaporation per square foot grate area per hour lb.	151·3	223·7	111·3	147·2	160·9	133·7	101·7	—	83·9
Water at 110 deg. F. evaporated per pound of coal	6·65	8·02	5·62	7·01	7·87	6·43	5·86	5·25	3·73
Water from and at 212 deg. F. evaporated per pound of coal	7·62	9·28	6·42	8·12	9·11	7·46	6·71	6·01	4·26
Water from and at 212 deg. F. per 10,000,000 British thermal units lb.	635·0	856·7	535·1	676·6	759·2	621·6	559·2	500·9	355·0
Temperature of inlet water deg. F.	110	110	110	110	110	110	110	110	110
Temperature of water after economisers ,,	230	335	no ecn.	195	225	no ecn.	no ecn.	no ecn.	no ecn.
Saving due to economisers per cent	11·0	20·4	Nil	7·4	10·4	nil	nil	nil	nil
Draught in chimney base on fan inlet in. W.G.	0·75	2·00	0·50	0·50	0·65	0·75	0·50	0·30	1·00
Temperature of gases leaving boiler, deg. F.	600	650	500	475	450	575	590	800	850
Temperature of gases at chimney base or fan inlet deg. F.	450	310	500	325	300	575	590	800	850
Analysis of feed-water—									
Permanent hardness deg.	9	5	12	6	3	9	9	9	12
Temporary hardness ,,	2	0	5	2	0	2	2	2	5
Percentage CO_2 in gases leaving the furnaces	7·5	12·0	5·0	6·0	12·5	5·0	5·0	5·0	3·75
Average gauge pressure lb.	75	159	60	155	160	150	70	70	55
Temperature of saturated steam deg. F.	320·3	370·2	307·3	368·2	370·7	365·9	316·1	316·1	302·9
Temperature of superheated steam deg. F.	nil	540	nil	530	650	450	450	nil	nil
Steam or power used auxiliary to the production of steam per cent.	2·5	2·5	5·0	2·0	1·5	2·5	nil	nil	nil
Efficiency—									
Net working per cent.	60·0	79·0	49·2	69·2	81·9	61·0	54·1	48·4	34·3
Boilers only ,,	54·7	59·5	51·8	60·3	65·8	59·9	54·1	48·4	34·3
Economisers only ,,	6·8	15·3	nil	4·9	7·6	nil	nil	nil	nil
Superheaters only ,,	nil	6·2	nil	3·4	9·7	2·6	nil	nil	nil
Cost in coal to evaporate 1,000 gallons of water pence	332·6	206·9	380·8	305·3	272·0	333·2	365·2	408·1	574·4
Coal bill for 20,000,000 gallons evaporation, £	27,472	22,748	32,166	25,688	22,920	28,120	31,886	35,000	49,818

a very short metal chimney and the draught is often aided by a steam jet in the base of the chimney. The boilers are, of course, hand-fired. There are hundreds of such boilers at work all over the country.

Such small boilers are worked on the same general lines. As regards evaporation, this can be estimated from the average figures, as being about 5½ lb. of water at 110 deg. F. per lb. of coal corresponding to 6 lb. of water from and at 212 deg. F. Very roughly, such boilers burn about 1 cwt. of coal an hour and evaporate about 60 gallons of water. The draught in the small chimney base is usually, say, 0·3 in. suction water gauge, but can be higher if a steam jet is used. The temperature of the flue gases is usually very high averaging 800 deg. F., whilst the percentage of CO_2 is about 5. Such plants are worked without superheaters, and, of course, economisers, and further, steam-jet forced-draught furnaces are rarely applied. The average net working efficiency can be taken as about 48 per cent. to 50 per cent.

"EGG-ENDED" BOILERS.

There are still a few old-fashioned "egg-ended" boiler plants at work at collieries. How many such plants are still running it is not possible to say, but the number seems to be now very limited. The usual dimensions of such boilers are generally 30 ft. to 35 ft. long and 5 ft. 6 in. diameter with a blow-off pressure of 60 lb. The boilers are placed high up on the top of a large brick firing-chamber, so that the bottom of the boiler is in the flames from the fire beneath, and the top half is in the open air, not insulated in any way. There is only one large firing grate, averaging in length 6 ft. by 6 ft. 6 in., and in width about 4 ft. 6 in., and the flames travel along the bottom of the boiler and straight up to the chimney, which is placed just behind the boilers. The height of the chimney usually averages 100 ft. to 140 ft. The firing is carried out by hand, and the fire-bars generally are of a very heavy type with very poor air space. Nothing in the way of steam-jet bars or other appliances seems to be used in connection with the firing of this type of boiler. Such a plant was the standard colliery practice not so many years ago.

In collieries the boiler feed water is heated by the exhaust steam of the winding and other engines, and generally goes into the boilers at about 150 deg. F. to 160 deg. F. average. As already explained, however, a given temperature of 110 deg. F. has been taken for the feed water for comparison, and the results altered by calculation. This, of course, does not alter the essential figure of the efficiency of the boiler itself.

On a typical "egg-ended" boiler of 30 ft. to 35 ft. long and 5 ft. 6 in. diameter, the amount of coal burnt is almost the same as a "Lancashire" boiler 30 ft. by 8 ft., corresponding to 22½ lb. of coal per square foot grate area per hour. The amount of water evaporated calculated as 110 deg. F. is, however, only about 250 gallons, practically only one-third of a "Lancashire" boiler plant, 30 ft. by 8 ft. The water evaporated per pound of coal is about 3¾ lb. with water at 110 deg. F., corresponding to 4½ lb. from and at 212 deg. per pound of coal. The draught on such boilers is usually very high, because the hot gases merely impinge on the bottom of the boiler and pass straight to the chimney. The chimneys used are of a fair height, say, 100 ft., so that with the very high flue-gas temperature of about 850 deg. F., the draught on the grates is naturally good. The feed water on such plants, being chiefly at collieries, is worse than usual, and can be taken as, say, 17 deg. total hardness. Because of the large open grates and generally inefficient brickwork setting, the percentage of CO_2 is very low and averages only about 4 per cent. The net working efficiency is about 35 per cent., which, of course, is a shocking performance. It is, however, only to be expected, because the flames and heat from the furnace are only in contact with the boiler for a few seconds, and then go straight up the chimney.

MIDDLESBROUGH PIG-IRON SHIPMENTS.—In the latest statistics issued by Messrs. William Jacks and Co., 5, East India-avenue, E.C., we find that the shipments of pig-iron from Middlesbrough, including Skinningrove, in November last were coastwise 3,031 tons, and foreign 9,612 tons, a total of 12,643 tons.

TRADE MARK LAW.

THE report of an appeal to the High Court from the decision of the Registrar refusing to accept the word "National" as a trade mark in a certain particular case has just been issued (R.P.C., vol. xxxviii, page 202), and some of the statements in the decisions are of considerable interest as indicating the aspect from which trade organisations are now being regarded in certain circumstances. The merits of the application are not being dealt with here, nor is it sought in any way to comment on the case, but it is instructive to note the line taken.

The applicant company had registered the word "National" as a trade mark in respect of certain goods, and sought to obtain registration for it for other hollow goods. The application was opposed by the secretary of a comparatively small association which included the bulk of the manufacturers concerned with these hollow goods.

The Registrar refused the application, and the decision was upheld by the learned judge, namely, that the word "National" although registrable in certain circumstances, was not free from objection in this particular case. The point on which great stress was laid was that in a previous decision the Court of Appeal in another case, in which the word "National" was employed, came to the conclusion that on the facts of that earlier case the word "National" was in those circumstances registrable.

The point of interest as to the trade association is contained in the decision of the Registrar. He states: "I have some doubt as to the decision I ought to come to in the light of all the facts and circumstances surrounding this case. I have come, however, to the conclusion that I ought, in my discretion, to refuse this application in view of the evidence of the opponent association representing, as I must hold, substantially all those engaged in the hollow-ware trade. To allow this evidence to affect the decision in this case is, in my view, in no way inconsistent with the general principle that the mere opinion of witnesses on the question to be decided by the tribunal is not relevant evidence. It is one thing to call a number of unconnected witnesses to say that the mark is in their opinion not calculated to deceive; it is quite another to have before one as evidence the united voice of a particular trade, declaring that, in view of the special circumstances of the trade, a particular mark is undesirable, and would cause prejudice to the other traders, and general deception and confusion.

"The principle of consulting the trade engaged where registration of a trade mark is applied for has already been recognised in two important industries, namely, the cotton trade and the steel trade, and I cannot but think that the principle is a sound one if the views of the united trade can be adequately expressed and brought before the tribunal. It seems obvious that the opinion and sentiments of the trade specially engaged ought, to say the least, to be given some consideration by the tribunal determining these cases, provided they are properly directed to the issues which have to be determined, and are based upon the special circumstances of the particular trade.

"I am inclined to think that with the increasing co-operation and combination of the trades and industries it may be possible to obtain more often in future the united opinion of any trade concerned upon trade mark applications; and that such united opinion ought to be given due weight. In the present case the opposing association, as far as I am able to judge, is clearly entitled to speak for the trade, and, in view of their evidence, I think it would be unwise to refuse to allow my discretion to be affected by so unanimous an opposition to the registration of this mark."

When the case came into the Court on appeal from the Registrar, the judge very carefully differentiated it from the previous "National" case, and referred to the Registrar's decision in the present action as a long and carefully-considered judgment, with which he entirely agreed.

Certain questions were put referring to the other trade marks on the register containing the word "National," and the judge summed up his view on these by pointing out that some of them were old marks and entitled to registration, others may have been registered on satisfactory evidence, and, with regard to the rest, he adds, "it may very well be that the registration ought not to have been allowed."

THE "CORONA" MOTOR CYCLE.

A MOTOR-CYCLE with some interesting points was exhibited by The Meteor Manufacturing Company, Limited, 98, Tollington Park, London, N. 4, at the recent Cycle and Motor Cycle Show at Olympia. This machine, named the "Corona" is of the conventional single-cylinder type with separate three-speed gear-box, but has an engine with several special features. Of this engine we subjoin an illustration.

In order to reduce the number of parts in the valve gear the valves are slightly staggered transversely and are inclined towards a camshaft placed above the crankshaft so that both valves are driven direct without rocking levers. A forged crankshaft is used, the big-end brasses being split and lined with white metal.

The cylinder is 72 mm. by 110 mm. (about 2⅞ in. by 4⅜ in.), and is cast in one with the crank-case, a cover being fitted on the side opposite the valve gear.

Although the cast-iron weighs a little more than aluminium, which is generally used when the crank-case is cast separately, the flanges and bolts which are then necessary to bolt the two together are not required, so on the whole, weight is probably saved while the construction is more simple.

A special feature is the lubrication, which follows the lines now usual in cars. A sump is provided below the crank-case, carrying a supply of oil sufficient for a considerable distance. A gear pump draws from this and delivers through a tell-tale, which can be seen by the rider, into a trough under the big-end which has the usual dipper. Separate oil tanks and pipes are therefore done away with, while the lubrication is much more perfect than with the ordinary splash. The magneto and oil pump are driven by a chain.

The motor-cycle is generally of the conventional type, but all the lugs used in joining the tubes are pressed from sheet steel in place of being malleable castings. The bearings of the front and back wheels are also of the non-adjustable type, in place of being of the cup-and-cone type. The non-adjustable type has proved the best in cars and should therefore be right in a motor-cycle. A very neat spring front fork is fitted having a short bell crank pivoted to the bottom of the fork and controlled by a horizontal spring.

THE JAPANESE NAVY AND OIL FUEL.—The *Osaka Mainichi Shimbun* states that the Japanese Navy Department some time ago gave an order in Great Britain for 200,000 tons of petroleum per annum, but the order was declined owing to the shortage of supply there. The order was then sent to America, but was again declined. This has dislocated the Government's naval plans, as it makes it dependent only on the domestic supply of oil, which is quite inadequate. It is feared, the Japanese journal adds, that unless adequate measures are taken a dangerous situation will arise in the event of any emergency.

STEAM-DRIVEN HIGH-PRESSURE FOUR-STAGE GAS COMPRESSOR.

CONSTRUCTED BY MESSRS. PETER BROTHERHOOD, LIMITED, ENGINEERS, PETERBOROUGH.

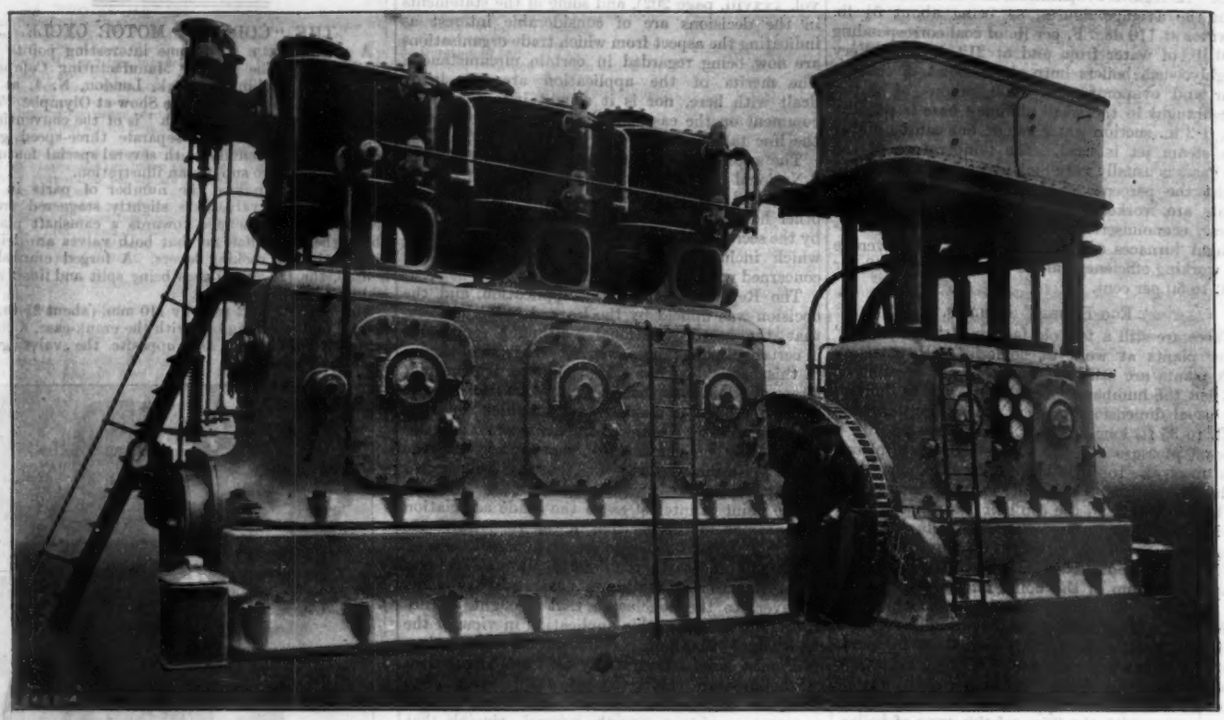
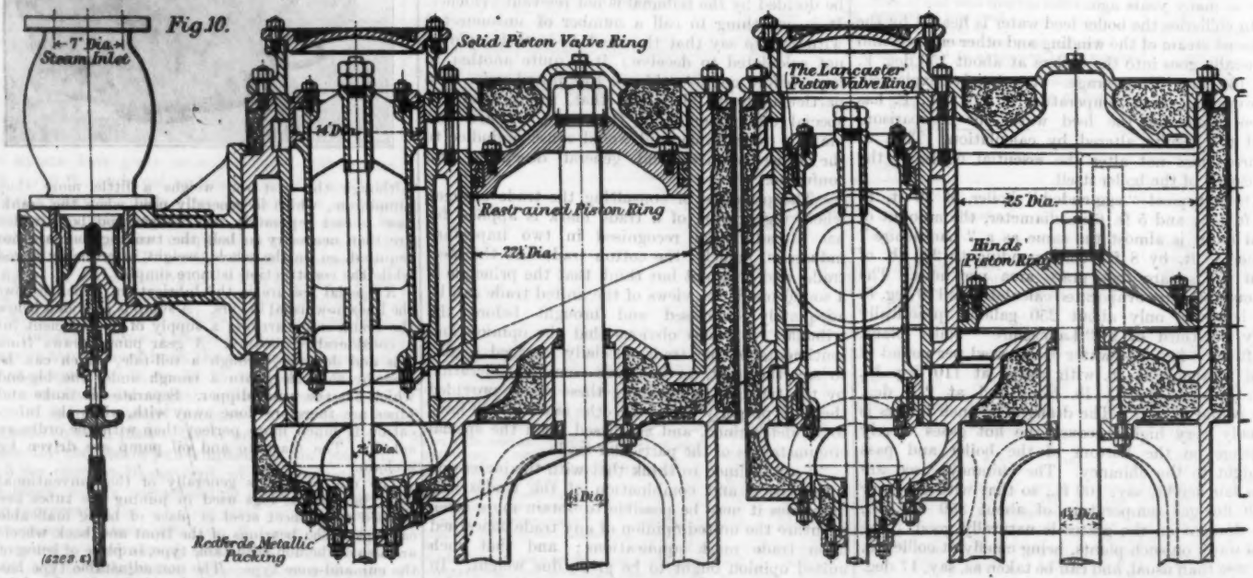


Fig. 9.

Fig. 10.



The design of air, or gas, compressors for very high pressure work involves a number of mechanical problems which are not met with when lower and more normal pressures have to be dealt with and some high-pressure machines recently constructed by Messrs. Peter Brotherhood, Limited, of Peterborough, are, for this reason, of much interest. These machines are of two types, one compressing to 2,250 lbs. in four stages and the other to 4,500 lbs. in six stages. We are able to publish detail illustrations of both these machines and will first refer to the four stage compressor of which various cross-sectional and other drawings will be found on Plate LXXIII, while a general view of the plant with its driving steam engine appears in Fig. 9 above. Sectional drawings of the engine appear on this page and also opposite. The 4,500 lb. compressor we will illustrate in a forthcoming issue.

The four stage machine illustrated is one of a number which were built during the war for the Government for the compression of mixed gases in connection with an extensive synthetic ammonia plant. The compressor is capable of compressing 1,000 cub. ft. of free gas per minute to a pressure of 2,250 lbs. per square inch when running at 200 r.p.m. It is driven by a three-cylinder, three crank, compound engine developing 650 brake horse-power when supplied with steam at 150 lbs. per square inch and exhausting at a pressure of 10 lbs. per square inch above the atmosphere. General arrangement drawings of the complete set are given in Figs. 1 to 4 on Plate LXXIII, while Figs. 5 to 8 on the same plate show the compressor in greater detail. Figs. 10, 11 and 12 give further views of the engine, Fig. 10, on this page, being an enlarged cross-sectional view of a pair of the engine cylinders and piston valves.

The general features of the compressor will perhaps be best followed from Figs. 5 and 6. From these it will be seen that the machine is arranged with three cranks, the piston rods of the first and second stages being driven from a common cross-head. These first and second compression stage cylinders are double-acitng, while the third and fourth stages are single-acting and are each driven from a single line of moving parts. The loading of the lines of parts and the work done by each is thus equalised. Coolers are arranged between each pair of compressions and after the last. The first and second stage water coolers are placed in a tank situated at the back of the machine. The third and fourth stage coolers are carried in a tank which surrounds the cylinders, as is best shown in Fig. 6. The compressed gas after leaving the last cooler is discharged through a separator to clear it of

ENGINE FOR HIGH-PRESSURE FOUR-STAGE GAS COMPRESSOR.

CONSTRUCTED BY MESSRS. PETER BROTHERHOOD, LIMITED, ENGINEERS, PETERBOROUGH.

Fig. 11.

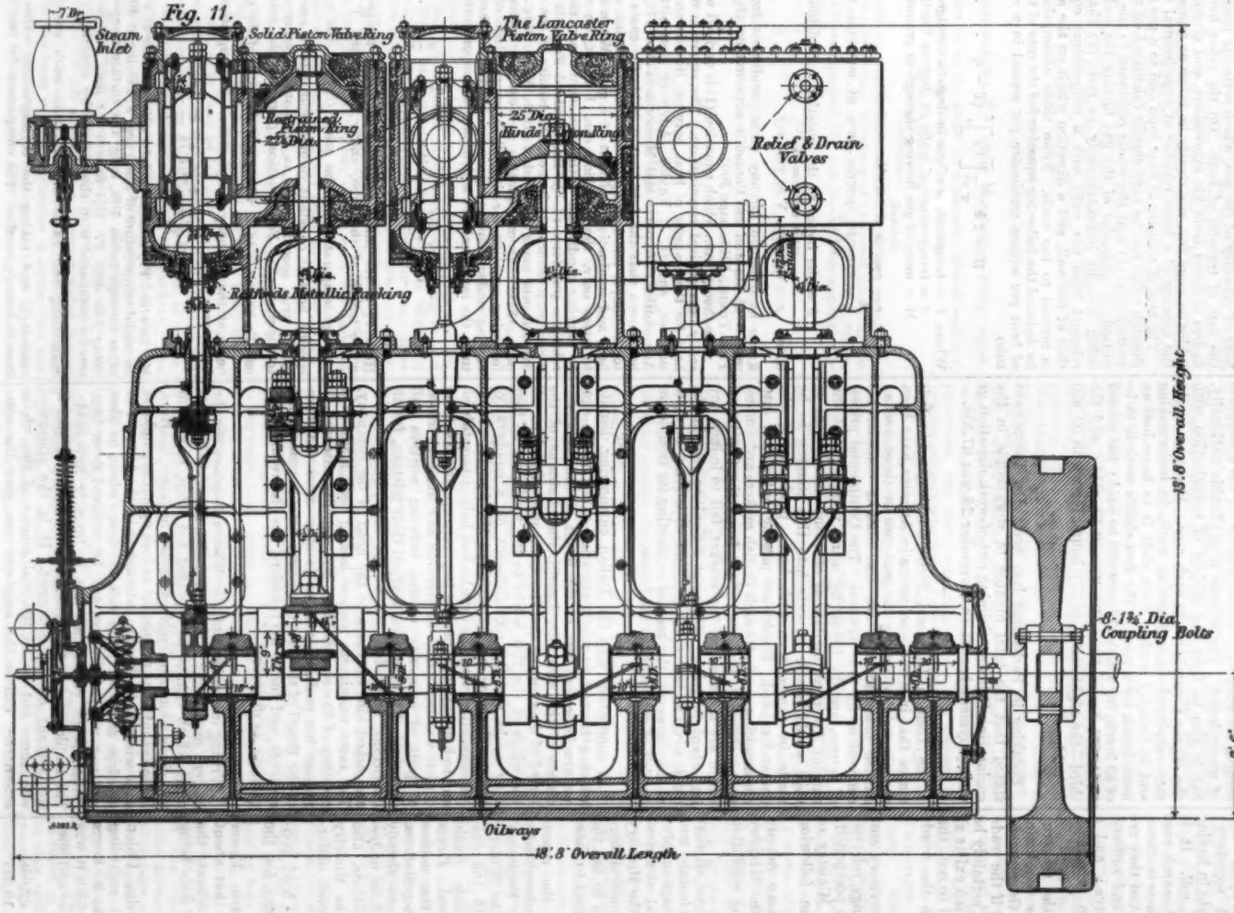
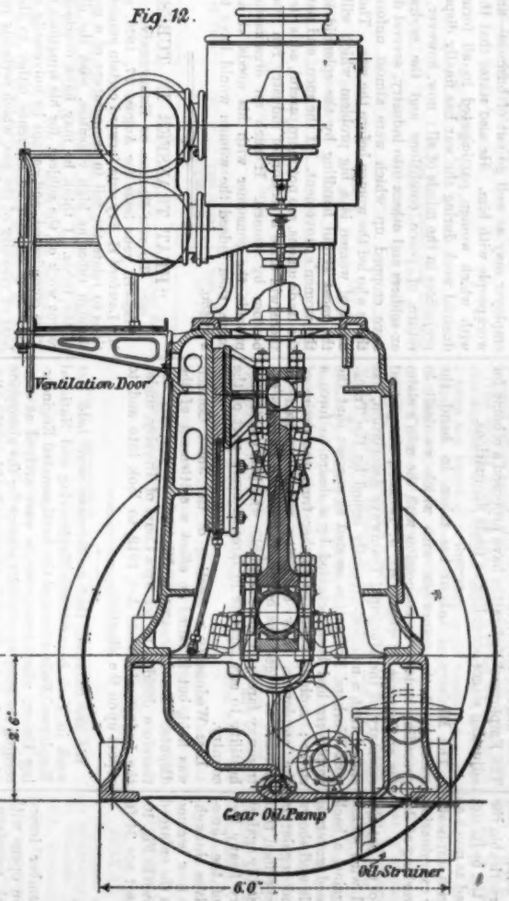


Fig. 12.



moisture before passing to the storage reservoirs. This separator can be seen to the right of Fig. 6. Water is continually circulated through the tank, which surrounds the cylinders and it will be evident from the figures that the cylinders and valve chests are in intimate contact with this cooling water service. The third and fourth stage coolers, which are placed in this tank, are comparatively small and do not limit access to the valves. The detail arrangement of the water-coolers is well shown in the larger scale drawings given in Figs. 7 and 8.

The first and second stage coolers are of the straight tube type with gas passing through the tubes, around which water is circulated. Any moisture deposited in the water-cooler is automatically projected into the discharge pipe by means of a small Venturi device inserted in the outlet branch. The first and second stage cylinders of the compressor are of cast-iron with bronze liners, while the third is of cast steel and the fourth is made from a solid forging, the valve chest and gland box being screwed on to the ends. The details of this and of the construction of the other cylinders is well shown in Figs. 7 and 8. Metallic packing for the plungers and rods is used throughout. The packing is made in the form of solid rings of bevelled cross-section and has proved itself capable of running for long periods without readjustment. The packing is carried in a detachable gland box which is screwed on to the cylinder barrel, and a spare gland box complete with packing is provided so that in case of necessity the whole thing may be replaced in a very short time. The high-pressure plungers may be taken out from below, in the space between the cylinders and the crank case by breaking the cotter joint in the rods. The valves, both suction and delivery, of the first three stages are of Brotherhood's "Mesta" pattern. This is a form of valve consisting of a light flexible plate. The final stage valves are of the spring-loaded poppet type made of high-tensile steel. The valves are of small diameter and a number are assembled in a common housing. It will be clear from a study of the figures that considerable attention has been paid to the question of the accessibility of the valves and that they and also the various connections may be got at without difficulty. In connection with this matter of accessibility for examination or repair, the form of joint which has been adopted for the valve chest covers and other connections is of importance. The joint is self-tightening and is independent of the tightness of the securing bolts. These bolts consequently have only to deal with the mechanical forces which come into play and no heavy spanner work is necessary in the compression of jointing material. The joint consists of a flexible ring pressed down into a Vee groove and of such section that internal pressure tends to expand the ring and make the joint tighter.

The understructure of the compressor is practically identical with that of the engine which drives it, as will be evident from a comparison of Figs. 5 and 6 with the illustrations of the engine given in Figs. 11 and 12 on this page. The compressor is somewhat the shorter of the two owing to the space occupied by the valves and eccentrics in the engine. It is not necessary to refer in any detail to the construction of this part of the set as it follows well-known enclosed high-speed engine practice. The rods and cross-heads are much on the lines of marine work. Forced lubrication is employed, a gear-driven rotary pump drawing oil

from the bedplate through an external strainer and delivering it to the bearings. As far as practicable the oil is conveyed through passages cored in the bedplate, the number of oil pipes having been reduced as much as possible. The oil strainer box is fitted with duplicate strainers so that one may be removed for examination or cleaning without interfering with the working of the compressor.

The engine, as we said at the beginning of the article, is of 650 brake horse-power, is supplied with steam at 150 lbs. per square inch and works against a back pressure of 10 lbs., at 200 r.p.m. A speed governor is fitted at the end of the crankshaft, as is well shown on Fig. 11. Provision is made for hand regulation over a considerable range and as it was specified that the engine should be capable of running steadily against full pressure at very slow speeds, a very heavy flywheel has been fitted. The engine is of the three-cylinder compound type with piston valves throughout. The arrangements follow what have now become fairly standard lines and are well shown in the enlarged part section of the valves and cylinders shown in Fig. 10. The overall dimensions of the combined set are 34 ft. by 20 ft. by 17 ft. 8 in. high.

(To be continued.)

INDUSTRIAL NOTES.

The monthly trade report for November issued by the United Patternmakers' Association opens with the following words from the general secretary: "Let us give thanks in that we are fortunate in having a small percentage on our unemployed roll. It is heart-searching to watch the unemployed march past our office windows in procession, bearing their mottoes, led by the mounted policemen . . . And they are remnants of that noble band who fought and suffered and died so that their country might live; and a grateful Government lets them march in procession rather than find them work."

For some members of the community the Government does too much, for others it does too little, and matters would be the same with any Government after a time. We are fully of opinion that if the trade unions did more than they do, there would certainly be in some trades much less unemployment than exists at the present time. In passing we are glad to note the phrase in the above statement in which the words "that their country might live" occur.

The threatened strike of technical, supervisory and executive engineers at electricity undertakings, referred to on page 682 *ante*, has been temporarily postponed, consequent upon the intervention of the Ministry of Labour, who issued on Monday last the following statement:—

"The National Joint Board for Electricity Supply Industry to-day met representatives of the Ministry of Labour, and intimated that the following resolution had been adopted —

"'The National Joint Board, having done all that is possible to secure the acceptance of the schedule, and having obtained the adherence of undertakings supplying upwards of 90 per cent. of the total electrical output of the country, decide to report to the Ministry of Labour that there are still certain undertakings which have not accepted the schedule, and to ask the Ministry to enter into negotiations with respect to these undertakings.'

"In accordance with this resolution the representatives of the Ministry of Labour subsequently met the Executive of the Electrical Power Engineers' Association, when it was agreed that, as the Ministry are about to enter into negotiations with the outstanding undertakings—negotiations which would necessarily occupy time—the Electrical Power Engineers' Association should suspend the notices against these undertakings pending the negotiations. So far as regards the undertakings that have already accepted the schedule in its entirety, and those undertakings which, as a result of the negotiations, also accept the schedule, it was agreed that the Ministry might intimate that the notices against such undertakings are withdrawn.

"Arrangements will now be made to hold conferences under the auspices of the Ministry for the purpose of further negotiations."

The assistant secretary of the Electric Power Engineers' Association stated on Monday that about 180 undertakings had definitely agreed to operate the schedule, the number standing out at the time being between 30 and 40.

Members of the Amalgamated Engineering Union have balloted on the proposed agreement regarding overtime, which it was proposed to limit to 30 hours in any four weeks, and night shift work, which it was proposed to pay for on a uniform basis of time and one-third for 47 hours. The ballot resulted:—

For acceptance	62,668
Against	19,517

The wages question is still the subject of negotiations. The Employers' Federation have proposed a scheme for adjusting wages according to trade fluctuations.

The Ministry of Labour has taken in hand the question of the tramways, with which we dealt in preceding issues. In connection with the men's claim for an increase in wages, Mr. J. Beckett, the general secretary of the Municipal Tramways Association, has stated that a manifesto recently issued by the Transport Workers' Federation seemed to suggest that the employers had been actuated by a desire to force a strike; nothing could be further from the desire of the employers. Any authority which granted an increase of wages was bound, in turn, to increase the tramway fares; it was the public who had manifested hostility to any increase in fares in every part of the country.

Last Wednesday a meeting of the Joint Council was held, but it failed to effect a settlement of the dispute. Dr. Macnamara, Minister of Labour, has therefore decided to set up a Court of Inquiry, under the Industrial Courts Act, 1919, to look into and to report upon the situation.

We are informed that conferences were held last week in York between the Engineering and National Employers' Federation and the Amalgamated Engineering Union, when arrangements were arrived at concerning the starting of a shift scheme for the absorption of unemployed. The scheme is applicable nationally, but is also to form the subject of consultation with the Works Committees in each case. It covers workmen employed on engineering work, in boilermaking and in foundry work. Each shift is to have half an hour break for a meal. The first shift's week is to be of 43 hours, for which 47 hours will be paid; the second to be 37½ hours, for which 47 will be paid; and the third—the night shift—of 37½ hours, for which 50 will be paid.

Speaking in Parliament last week, Dr. Macnamara stated that the total number of workpeople in the engineering industry claiming out-of-work donation or unemployment benefit on November 26 was 67,558.

The London Iron and Steel Exchange, Limited, states that iron and steel prices in America have been sharply reduced during the past two or three weeks; British manufacturers are also making considerable concessions for firm business. The Continental prices, of course, are the lowest by many pounds; but the current American quotations on many descriptions of steel would enable imports into this country to be made in competition with home producers if the demand existed. Stocks are passing but slowly into consumption, and although British makers are finding trade stagnant the low offers from the Continent, which are a feature of the market, fail to induce any important business. Financial difficulties remain the chief adverse factor in the world situation; in spite of this, however, the market is meeting its troubles in a spirit of confidence in the future.

In connection with the Italian engineering dispute which attracted so much attention a few weeks ago, we are informed that as the result of the socialistic claims of the men, Mr. Agnelli, the chairman of the board of directors of the Fiat Company, offered to sell the whole of the Fiat works to the workmen, so that they could run the establishment on a co-operative basis. The offer was refused, and Mr. Agnelli severed his connection with the firm he had helped to establish and to build up to its present important position, stating that it was impossible to carry on any business whilst a spirit of animosity existed between workers and directors. The men soon realised their mistake, for an important delegation waited on their former chief and asked him to return to the head of the company. The same unanimous request having been made at a meeting of the shareholders, Mr. Agnelli consented to resume his position, and he is once more chairman of the Board of the Fiat Company. Mr. Fornaca, chief engineer, and one of the founders, has also resumed his position as director.

Writing in the issue of *The Woman Engineer* for the current month, Sir William Beardmore makes a statement which cannot be repeated too often, in view of the views which are freely expressed in many quarters. He says that some people like to look upon the employer as a wicked old despot, entrenched in the fortress of privilege and power, and able to engage whom he likes and pay whatever wages can be extorted from him. Under peace conditions this is literally impossible. The employer, however generous and philanthropic, is the servant of the consumer. It is the consumer who turns out to be the real master of the whole situation. Unless the employer can give the consumer his requirements at an attractive price, the employer may as well go out of business—and all his workpeople with him. He also states that the success with which women participated in all forms of industrial work during the war has finally dispelled any prejudices in the minds of all; now, however, with the return of peace conditions and the re-drafting of ex-soldiers and others into industry, several difficulties have cropped up which were almost unforeseen by those who led the women before the war. The employment of women is a big problem which will call for the most skilful handling by the splendid leaders of the women's movement. If the men, and particularly the trade unions, are not more careful, adds Sir William, there will arise a section of industry run from top to bottom by women. If such an organisation could provide the consumer with his needs at a cheaper price, then indeed the woman would have taught us a lesson.

"HEAT TRANSFER IN TUBES."

To the Editor of Engineering.

Sir,—In your issue for August 27, 1920, page 265, Mr. Lawford H. Fry puts forward certain empirical equations to relate the fall in temperature of a gas moving through tubes at high velocities, with the dimensions of the tubes. I think he may have overlooked some recent work on the subject, for his equations are somewhat complicated, and cannot be universally applicable since they contain no reference either to the specific heat or viscosity of the gas, which certainly must affect the rate of transfer of heat. On the other hand, the figures deduced from his expressions, and given in the tables on page 265, can clearly be taken as representing the average of a large number of experimental results.

The rate of transfer of heat from and to a gas flowing through tubes can be very closely calculated on the two assumptions (1) that the whole resistance to the flow is caused by molecules of the gas hitting the walls and being brought instantaneously to rest, (2) that they rebound from the walls with a temperature equal to that of the wall, and a direction which on the average is normal to the walls. From these assumptions can be deduced the following equation for the rate of transfer of heat per square centimetre per second in a circular tube

$$H = 2k\,\frac{M}{\pi r^2}\left[C_v\right]_t^T (T - t) \quad . \quad . \quad (1)$$

Where T = temperature of gas in degrees Centigrade.
t = temperature of walls in degrees Centigrade.
M = mass of gas flowing through in grammes per second.
r = radius of tube in centimetres.
$\left[C_v\right]_t^T$ = average specific heat at constant volume t to T.
k = the factor in the question: Resistance per unit area = $R\,\rho V^2$,
where ρ = density, V = velocity.

k can be obtained for any given conditions from the results of Stanton and Pannell's experiments (Ry. Soc. Phil. Trans., 1914, page 200).

The theory from which equation (1) is derived will not really bear critical examination. The equation will not hold for the transfer of heat between liquids and solid surfaces, and G. I. Taylor (Advisory Committee for Aeronautics: Reports and Memoranda No. 272, 1916) has shown that the fact that it holds for gases is due to the simple relationship between the viscosity, specific heat and conductivity of heat of a gas. When applied to gases only, the equation can, I think, be applied to varying conditions, with more confidence than the relations put forward by Mr. Lawford Fry. It reproduces very accurately indeed, the results of the careful experiments made by Jordan (Inst. Mech. Eng., 1909, page 1317). From equation (1) can be derived the following equation for the fall in temperature of a gas flowing under constant pressure conditions through a tube, the inner walls of which have a temperature t.

$$\log\frac{T_1 - t}{T_2 - t} = 1{\cdot}74\,k\,.\,\frac{\left[C_v\right]_T^t}{\left[C_p\right]_T^t} \times \frac{x}{r} \quad . \quad (2)$$

Here T_1 is the inlet, and T_2 the outlet temperature, x the length of the tube, and r its radius. T is the average temperature of the gas. $\left[C_v\right]_T^t$ is the average specific heat at constant volume from t to T and $\left[C_P\right]_T$ is the true specific heat at constant pressure at the temperature T. For practical purposes the ratio can usually be taken as $\frac{1}{\gamma}$ where γ is the ratio of the specific heats at the ordinary temperature. The equation then becomes:

$$\log\frac{T_1 - t}{T_2 - t} = 1{\cdot}74\,\frac{k}{\gamma}\,.\,\frac{x}{r} \quad . \quad . \quad (3)$$

Mr. Lawford Fry considers, *inter alia*, the case of a gas at an initial temperature of 2,000 deg. F. flowing at different rates through tubes 5 ft. long, the surface temperature being 380 deg. F. His figures for final temperatures can be compared with those given by equation (3), by calculating the value of $\frac{P\,V\,d}{\eta}$ in each case, (η = viscosity), and taking the corresponding value of k from Stanton's results. The comparison for one or two

cases is given in the following tables, the calculations being made for air ($\gamma = 1{\cdot}42$).

TABLE I.

M = 100 lb. per hour.

Diameter of Tube.	k.	Final Temperature from Equation 3.	Final Temperature given by Fry.
		Deg. F.	Deg. F.
0·5 inches	0·0031	580	600
2·0 ,, ...	0·0048	1,100	1,080

TABLE II.

M = 800 lb. per hour.

Diameter of Tube.	k.	Final Temperature from Equation 3.	Final Temperature given by Fry.
		Deg. F.	Deg. F.
0·5 inches	0·002	800	760
4·0 ,, ...	0·0033	1,600	1,560

The above examples are chosen because they represent the extreme conditions of the more reliable experiments quoted by Fry. There is one isolated case quoted where the diameter was 6 in., but in most of the experiments it was under 2 in. The greatest value for the weight of gas per hour in these experiments appeared to have been about 600 lb. per hour, the majority being under 400 lb., but Fry stretches his empirical relationships to cover flows of 1,600 lb. per hour. This is dangerous since his equations are deduced directly from the average results of experiments at lower rates, and therefore extrapolation beyond the range is uncertain. Further Fry gives figures for flows of 100 lb. per hour through tubes of 4 in. and even 8 in. in diameter, whereas the flow in such cases will not necessarily be turbulent and hence the same laws for transfer of heat do not apply.

When the tube is not circular in cross-section, equation (3) still holds if the ratio

$$\frac{\text{Internal surface area}}{2 \times \text{cross-sectional area}}$$

is substituted for $\frac{x}{r}$: other conditions being equal, k appears to be the same for a circular tube of radius r, as for a non-circular tube of which the

$$\frac{\text{Cross-sectional area}}{\text{Perimeter}} = \frac{r}{2}.$$

When the drop in temperature t is not very great compared to the average difference of temperature θ between the gas and the walls of the tube, the following equation, derived from equation (3), can be used for approximate calculations.

$$\frac{t}{\theta} = 2\,\frac{k}{\gamma} \times \frac{\text{Internal surface area}}{\text{Cross-sectional area}} \quad . \quad (4)$$

When the flow is high, $k = 0{\cdot}002$, and the rise or fall in temperature is independent of the rate of flow.

Yours faithfully,
H. T. TIZARD.

20, Stoverton-road, Oxford, December 9, 1920.

"WELLS AND GROUND WATER."

TO THE EDITOR OF ENGINEERING.

SIR,—In view of the article on page 727 of your issue of the 3rd inst. under the above title, your readers may be interested in two matters which came to my notice in a certain part of Mesopotamia. The district I refer to is pure desert, not alluvial plain, but a sandy and gravel tract south of the Euphrates, formerly of course covered by sea, which we know extended up to Ur of the Chaldees in historic times. The gravel beds in this area are so cemented by gypsum that they stand up in a straight, clean face without timbering, when trenched for considerable depths. The gypsum is present in such quantities that the Arabs are in the habit of just cleaning off the surface dust and sand, and then lighting fires of camel thorn, collecting subsequently from the spot white plaster of paris ready after grinding for use. Here and there in this district are to be found strata of clean, loose river sand, without gypsum, sandwiched in between layers of this gypsum and gravel. The water of this area is practically all bitter, except at a few isolated wells, round which there are usually gardens, these little oases being miles distant from any town of size. There are to be found at some distance from these, in certain cases, rectangular shafts 10 ft. or 20 ft. deep, dug through the gravel stratum, and finishing, as I could judge, in a clean sand stratum below, where there naturally was a certain amount of caving. These shafts appeared to be dug in the dips by which surface water would drain away, and as far as I could discover they were intended to catch this water and transfer it to the sweet sand below, from which stratum it was, of course, drawn off by the sweet water wells of the gardens. The long summer heat and the slow absorption of the top soil results in most of the surface water running off the land. Even after heavy rain the penetration is often extraordinarily small, merely an inch or so. It appeared to me that these shafts really formed part of a scheme for the conservation of sweet water, below ground, and therefore away from evaporation. Any one who has been in these countries is aware that the native has mechanically done certain things in certain ways for so many centuries that both origin and reason are often lost, and it is not surprising therefore that I could never secure definite information on this point.

The second point is that once a sweet water well in this district is over pumped, it turns bitter and is ruined. I have not heard of a well thus spoilt becoming sweet again, and usually they are abandoned by the Arabs. Our forces spoilt several wells in this way before they realised what was happening. The reasons for this phenomenon appear obscure, but I suggest that the sweet water exists in pockets kept supplied by surface water filtering through fissures in the strata, and that these areas are surrounded by bitter water. If the fresh is present in sufficient quantity the bitter would be held back, there probably being a zone of dilutely bitter water between the two. If the sweet water is not drawn upon too heavily before the rains come and the supplies replenished, it seems possible that the bitter water will never actually approach the well; the bitter water in this way would constantly be approaching and receding from the well, or I should say the depression which the sweet well taps.

I have discussed both these matters on the spot with engineers from India, but they were apparently outside their previous experience. Perhaps the writer of your article can throw some light on them.

I am, yours, &c.,
"I.M.E.F."

THE FUTURE OF THE ENGINEERING PROFESSION.

TO THE EDITOR OF ENGINEERING.

SIR,—Engineering is the youngest, by several centuries, of all the highly-skilled professions; in fact, it is hardly yet out of the nursery. It is still at an age when fond parents make wild, and inaccurate, prophesies about the future career of their offspring. Let us avoid that attitude, and base our forecast, not on our own hopes, but on the life history of the adult professions.

Of the older professions, the one most akin to engineering is surgery. The surgeon is a highly-trained expert, who is called upon to solve problems of everyday occurrence in the light of the most up-to-date scientific theories; he has to apply these theories to his daily practice. The case of the engineer is similar, and it is clear that the influences which have moulded the medical profession will exercise a like effect upon engineering.

In the medical profession, we find a highly-organised body, which admits only those who have qualified themselves by a long course of study, and by passing certain examinations. As a further safeguard for the profession, the state refuses to allow any person to practise surgery who has not the foregoing qualifications. These restrictions have been imposed partly by the surgeons in their own interests, but chiefly by the State, in the interests of the public. These two sets of interests are similar, but not identical. If the public and professional interests come into conflict, it is certain that the public interests will ultimately prevail.

The relations between the public and the engineering professions are exactly similar. The public requires that it shall not be exploited by unqualified men, posing as engineers; the engineers require that the unqualified man shall be prevented from taking the bread out of their mouth. So far both interests are identical; both can be satisfied by a regulation preventing unqualified men from calling themselves engineers, or from practising as such.

Beyond this point, the interests of the public, and of the engineering profession, begin to divide a little. The public demand that they shall be given full value for their money, the engineers demand that they shall be given full money for their value. And so the question arises, "What is the value of an engineer?"

Only a general answer can be given. It is clear that the pay of an engineer must be sufficient to provide him with a wage equal to that earned by other brain workers of similar capacity, such as surgeons, physicians, lawyers, and the higher grades of accountants and civil servants. In addition, the pay must be sufficient to recoup the engineer for the cost of his education. If these conditions are fulfilled, there will never be any lack of candidates for the engineering profession.

In return for a wage based on the above considerations, the public will demand that every engineer shall be fully qualified—in fact as well as in name. This is a matter that can only be dealt with by the engineering profession. It is too big a question to be dealt with here in detail, but the salient features may be indicated.

Money spent on sound education and experience is never wasted, because the market price of a man is, on the average, his true value. In other words, an all-round rise of pay can only follow an all-round rise in skill and education. The science of engineering is developing very rapidly; new methods are being introduced every day; consequently a man who is a fully-qualified engineer to-day will be hopelessly out of date in ten years time, unless he has, in the meantime, been actively studying.

Perhaps it may ultimately be necessary to date every engineering degree and qualification, so that the public may have a rough guide as to the freshness, or otherwise, of an engineer's knowledge. For instance, a university granting a degree would add the date as an integral part of the degree, to be included in every reference to it. Thus a man with a university degree would describe himself as "B.C.E. 1910." Bachelor of Civil Engineering, degree granted in 1910.

This method would, of course, involve the setting up of a system by which degrees would be renewed. Such a system would necessitate the holding of yearly examinations in recent engineering developments, open to all engineers who already hold a degree. Thus, an engineer who passed the examination this year would add the renewal date to his degree, which would then read, "B.C.E. 1910, 1920."

This is perhaps a revolutionary suggestion, but the system is not new, for it has been working in the Army for many years. Every officer must pass an examination before he can be promoted, so that his knowledge and efficiency are tested at short intervals.

Engineering now includes so many specialised branches, that it is impossible for one man to master them all. The tendency, therefore, will be for engineers to differentiate themselves into general practitioners, and specialists. The general practitioner will carry out the work, but will call in the specialist to design the more specialised parts. In this connection it is probable that engineers will find it advisable to adopt the system which is known in the medical profession as "team work." Under this system, groups, or firms of engineers, would be formed containing a nucleus of general practitioners, and a specialist for each specialised branch of engineering. An organisation of this nature would be in a position to outstrip any individual engineer, both in efficiency of design, and economy of construction.

I am, yours truly,
"ONLOOKER."

December 10, 1920.

ROYAL METEOROLOGICAL SOCIETY.

THE usual monthly meeting of this society was held on Wednesday, the 15th inst., at the Society's Rooms, 70, Victoria-street, Westminster, Mr. R. H. Hooker, M.A., President, in the chair.

Mr. C. K. M. Douglas, B.A., read a paper entitled "*Temperature Variations in the Lowest Four Kilometres.*" The chief object of this paper is to emphasise the importance of the source of the air supply in causing variations of the upper air temperature, and to discuss the relationship of these variations to the weather changes, with special reference to the theories of Professor V. Bjerknes, which the observations strongly support. The view put forward is certainly not disproved by statistical results, though the evidence for it is derived chiefly from the study of a large number of observations of temperature and humidity in the upper air, in conjunction with synoptic charts. Among the associated points mentioned in the paper, the following may be emphasised: (1) Both troughs of low pressure and wedges of high pressure normally lie farther west in the upper air than at the surface. (2) The pressure in the upper air may be regarded as being partly a consequence, and not purely a cause, of the temperature of the underlying column. (3) Very powerful wind currents are observed at great heights between the polar and the equatorial air at these levels.

A second paper was brought forward by Mr. A. P. Wainwright, entitled "*A Sunshine Recorder (Mechanical Type).*" The new type of sunshine recorder is in the form of two mercury thermometers similar to one another and of fairly large capacity. The bulb of one thermometer which is contained in a vacuum, is exposed to the direct rays of the sun while the other is contained in the shade of a Stevenson screen. The difference in expansion of the mercury in each bulb is recorded mechanically by means of a pointer on a clockwork drum, and denotes the varying intensity of the sun's radiant heat at any hour of the day. This instrument is devised with a view to obtaining a more detailed record of sunshine, and in particular to showing the total intensity of the sun's rays for the day as apart from the number of hours the sun has actually put in appearance.

A paper by Lieutenant-Colonel J. E. E. Craster, O.B.E., Ordnance Survey, entitled "*An Investigation of River Flow, Rainfall and Evaporation Records,*" was also read. Measurements of the flow of the Shannon show a fluctuation due to variations in the amount of rainfall, and evaporation, in the Shannon Basin. Rainfall records for the Shannon Basin are few, and there are no evaporation records, so that it is not possible at present to determine the amount of rainfall and evaporation by direct methods. But the monthly variations of the rainfall and evaporation, expressed as fractions of the total annual rainfall and evaporation, are constant over large areas. Records of evaporation from the soil have been kept at Rothamsted, for many years, and in the absence of any Irish records it has been necessary to employ these. By using the monthly variations of rainfall and evaporation as described above, it is possible to determine the minimum annual rainfall and evaporation in the Shannon Basin, which will account for the fluctuations in the river flow. The minimum annual rainfall has been found to be 45·71 in., and the minimum annual evaporation from the soil 16·88 in.

THE SURVEYORS' INSTITUTION; THE INSTITUTION PUBLICATIONS.—Following a recommendation by the Special Committee of the Surveyors' Institution which was set up to consider and report upon the future policy and activities of that body, the council have been inquiring into the possibility of adding to the value and interest of the Institution publications by changes in their form, contents, or method of issue. They have come to the conclusion that a monthly publication to include the papers and discussions at present contained in the Transactions, the Professional Notes, and any other printed matter issued to members, would have the advantage of circulating information at more frequent and regular intervals, and would therefore be likely to prove more convenient to members. At the end of the present session, therefore, a publication will be issued monthly to comprise all the matter which is now circulated in different forms; but the Transactions will be included as a separately-paged supplement or appendix, so that members desiring to continue this series in its present form, and to bind the papers and discussions separately, may be enabled to do so.

THE MEETING OF THE ITALIAN SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS AT GENOA.

A meeting of the Italian Society of Naval Architects and Marine Engineers, held at Genoa on December 4, 5 and 6, was attended by Sir Westcott Abell, Mr. R. W. Dana (secretary of the Institution of Naval Architects) and Mr. B. J. Ives (principal surveyor for the Continent for Lloyd's Register of Shipping). The inaugural meeting of the Society began on Saturday, December 4, and was held in the Palazzo San Giorgio, lent for the occasion by Signor Ronco, the chairman of the Harbour Board, who gave an address of welcome to the Society. The Minister of the Navy and the Minister of Transport had sent official representatives, who were present throughout the meeting.

Speeches were also made by Professor Scribanti and Signor Nabor Soliani, after which the president asked Signor Soliani to read his paper on the "Future of Warships." This paper was followed by a contribution from the President entitled "The Technical results of the Battle of Jutland." The discussion on these two papers was taken together, and Mr. Ives read, in Italian, a contribution on the subject from Sir Eustace D'Eyncourt (the Director of Naval Construction of the British Admiralty).

These two papers were very interesting, in view of the discussion now taking place in England on the new naval programme. The type of ship proposed by Signor Soliani was of the semi-submersible class without side armour in the ordinary sense, but protected on the surface by a heavy turtle-back deck, and below water by a wing tank and bulkhead protection against torpedo attack. The vessel was provided with two barbettes, with two guns each, with a forecastle, and armoured towers for control and for inlet of air. With the type adopted, it was possible to protect against damage from aircraft, while, as regards gun attack, the target offered was very small indeed. Moreover, the cost of construction was considerably reduced by the omission of the heavy and expensive side armour.

In the evening the Syndico (the mayor) gave a reception to the Society at the Municipal Palace, and welcomed the representatives of the British Institution of Naval Architects. Sir Westcott Abell replied in English.

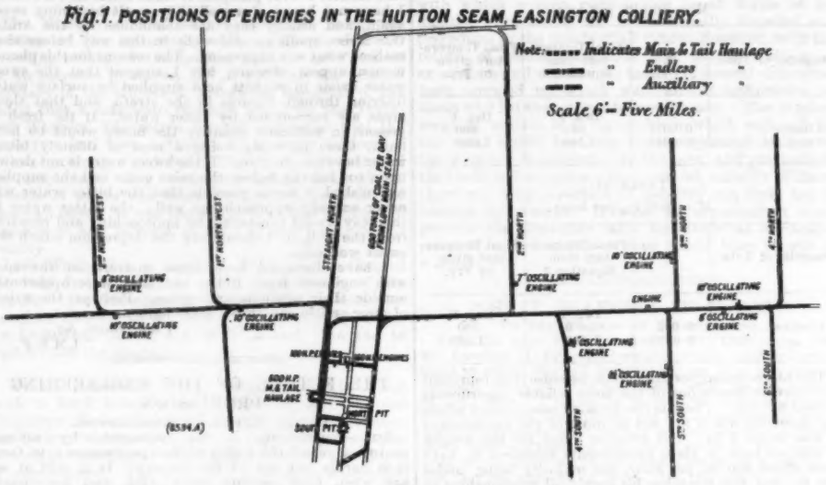
The second day's meetings, on December 5, began with a paper by Sir Westcott Abell on the "Subdivision of Passenger Vessels." This contained an account of the present position in regard to the international regulations. The discussion was opened by Professor Scribanti, and continued by Director Barricelli, of the Registro Navale Italiano, who suggested that the Government should appoint a Technical Committee to study, not only this question, but also the freeboard of cargo vessels, which suggestion was carried still further by Colonel Ignarra, who suggested the committee should have even wider powers. Ing. Ghirardi drew attention to the great need of associating with these technical questions the effect of the proposed regulations on the economic operations of the shipowner. He was glad to see that in the paper under discussion some attempts had been made to embody these views. Senatore Orlando drew attention to the work that had been done by the Commission appointed in 1917 to study the vulnerability of ships, and considered that the question should receive careful study at the present time. Colonel Bonfiglietti proposed a vote of thanks to Sir Westcott Abell for his paper, to which the latter replied briefly.

Professor Scribanti then read a paper in which he was joint author with Ing. Bernati, on "Two New Types of Hull for Cargo Ships." The first part of the paper related to a method of construction which had been invented by Colonel Vitulli, in which it was proposed, by the adoption of an elliptical cross-section of hull, to effect certain economy of weight and labour by virtue of the resistance to deformation offered by this particular form of hull. The second part of the paper dealt with a type of vessel in which it was proposed to embody as integral parts of the structure tubes of large diameter, which form of construction it was considered might result in economy of weight and labour. Considerable discussion took place on this paper.

The meeting was adjourned until the afternoon, when other papers were proceeded with, including a contribution on "The Block Coefficient considered as an Economic Factor for Passenger Vessels," an interesting paper read by Signor Mengoli, the chief surveyor of the Registro Navale Italiano.

In the evening, the official dinner of the Institution was held on board the mail steamer Esperia, belonging to the Societa Italiana di Servizi Marittimi. On Monday, December 6, a visit was paid to the various establishments of Messrs. Gio Ansaldo and Co. Signor Soliani, the Director-General of the shipbuilding yards, and Signor Virgilio conducted the visitors, in the first instance, to the Cantieri Navale di Sesti Ponente. They then proceeded to the steel works of Messrs. Ansaldo, where they inspected the machinery for the manufacture of armour plates, including a 15,000-ton forging press. They also witnessed some of the operations necessary for the construction of cast steel chain cables. From there progress was made to the Cantiere Savoia and to the Stabilimento Meccanico di Sampierdarena, which works are devoted to the construction of boilers, of reciprocating and turbine machinery, as well as locomotives.

ELECTRIC PLANT AT THE EASINGTON COLLIERY.



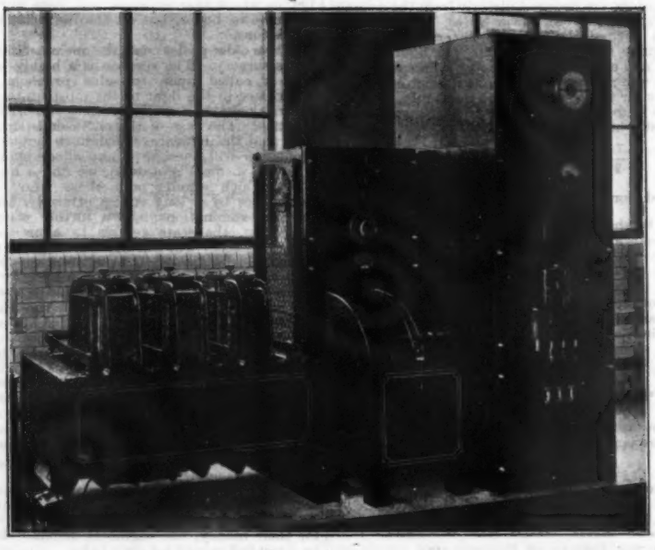


Fig. 2. Kapp Phase Advancer and Control Gear for Fan Motor.

ELECTRIC HAULAGE AND VENTILATING PLANT AT THE EASINGTON COLLIERY.

As an example of a modern electrical haulage installation for underground colliery work the plant recently put down by the Easington Coal Company, Limited, at their pits at Easington, County Durham, is of considerable interest. The colliery is a comparatively modern one, and the underground haulage is on an unusually complete scale. The electric power supply to the colliery is obtained from a 350-kilowatt mixed-pressure turbo-alternator, supplied with exhaust steam from the main winding engine; but, in addition, a supply is taken at 2,750 volts and 40 periods from the mains of the Cleveland and Durham Power Company. The larger motors are supplied direct at this voltage, but transforming plant, stepping down to 440 volts, is installed for the supply to the smaller motors. The various electric haulages comprise two large main-and-tail haulages of 600 horse-power and 450 horse-power respectively, and three endless haulages, two of which are of 160 horse-power, and the third of 85 horse-power. There are in addition various oscillating engines which feed the main haulages from the various landings.

The 600 horse-power main-and-tail haulage is situated in the South Pit, or Hutton Seam, a plan showing the working of which is given in Fig. 1 on this page. The haulage gear itself is illustrated in Figs. 3 and 4 and Fig. 7 on page 808. The whole of the mechanical equipment in connection with this and most of the other haulages was supplied by Messrs. M. B. Wild and Co., Limited, of Nechells, Birmingham, while all the electric motors and gear were supplied by Messrs. The General Electric Company, Limited, of 67, Queen Victoria-street, London, E.C. 4, and Witton Works, Birmingham. The length of the haulage road over which the gear operates is 2,323 yards, and it has an average inclination of 2 in. per yard, with a maximum of 3 in. The number of trams dealt with per journey is 66 to 68, each weighing 6¾ cwt. and carrying 10¼ cwt. of coal. The average time taken for the journey is 12 minutes, and 1,135 tons of coal are raised per day of 15 working hours.

Each of the two haulage drums is 6 ft. in diameter, with 9 ft. diameter flanges. The width between the flanges is 3 ft. and the shaft is 12 in. in diameter. The drums are made in halves of ⅜ in. mild steel plate, riveted to steel angle circles. The flanges are also in halves, of 1 in. mild steel plate, and are stiffened with angles and channels. Cast iron brake rings of angle section are bolted outside each flange. The drum bosses are of cast steel, made in halves and

ELECTRIC HAULAGE PLANT AT THE EASINGTON COLLIERY.

Fig. 3.

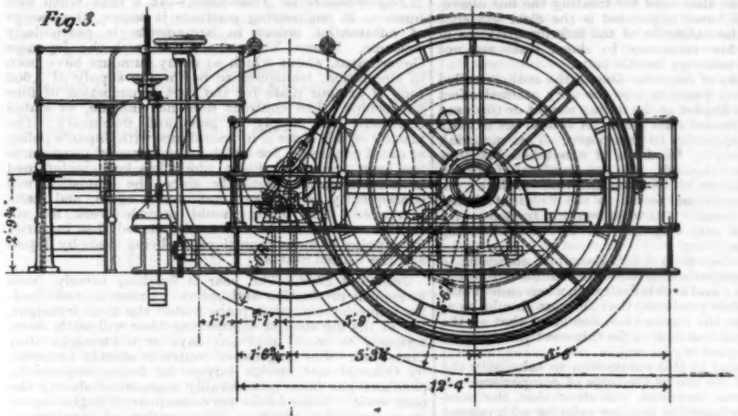


Fig. 4.

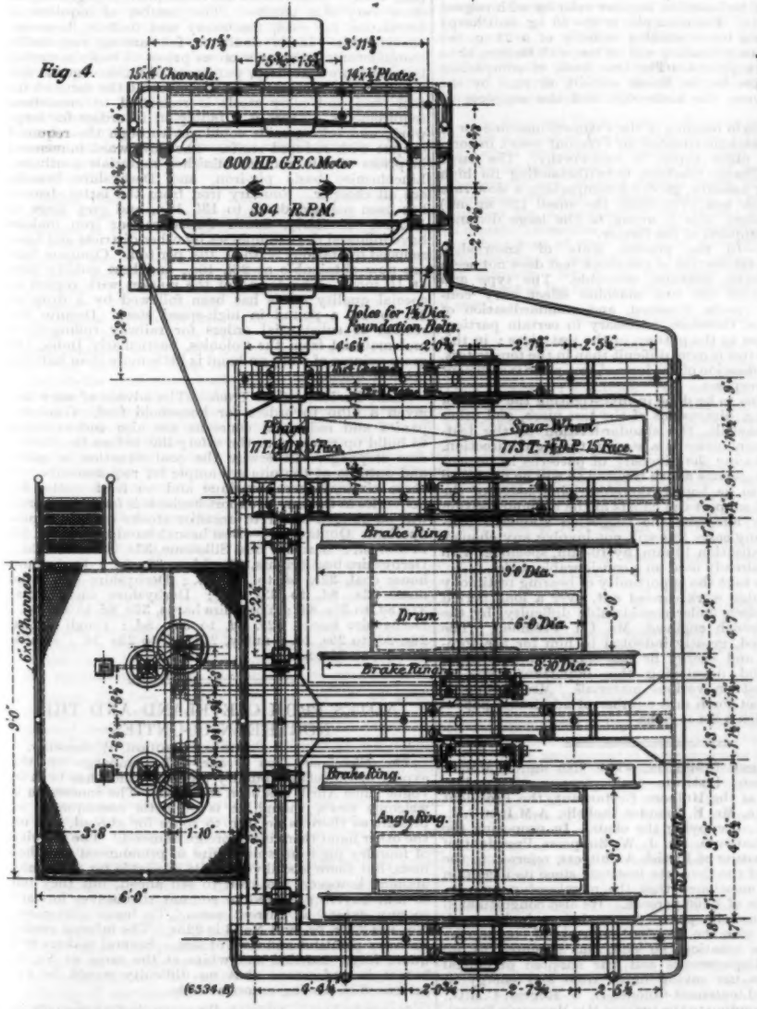


Fig. 5.

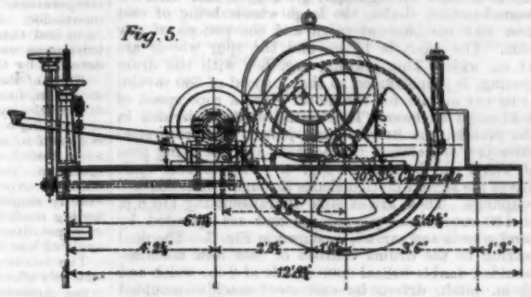
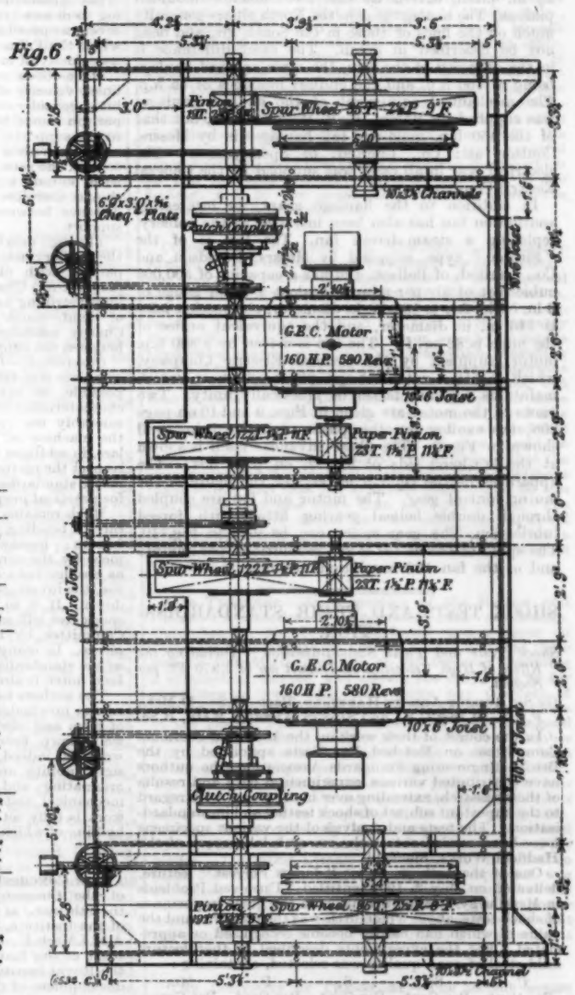


Fig. 6.



bushed with gunmetal. The drum half of the clutches are cast as part of the bosses, and are fitted with renewable steel wearing faces. The loose halves of the clutches are of the two-jaw type of cast steel, and slide on hexagonal seating on the shaft, the clips working in the clutch races being of cast iron. The clutches are operated by means of shafts and levers from the hand wheels in front of the machine, as shown in Figs. 3 and 4. Each drum is fitted with two mild steel strap band brakes, which are lined with Ferodo fibre. The brakes are operated either by foot levers or hand wheels and screws, as can be seen from Figs. 3, 5 and 6.

The "Witton" motor which drives the haulage is of 600 horse-power capacity. It is of the three-phase enclosed slip-ring type and is supplied with current at 2,750 volts. The motor runs at 394 revolutions per minute and is connected to the haulage through a double helical gear with forged steel wheels and a ratio of 10 to 1. A flexible coupling of the felt and wood pad type is interposed between the motor and the gearing. The gears are machine-cut and were supplied by Messrs. The Power Plant Company, Limited, of West Drayton, Middlesex. Other details of the haulage gear will be followed from our figures. It will be seen that the drum shaft runs in four main bearings and that the motor shaft has two bearings on the main bedplate. These two latter bearings are ring-oiled. The bedplate itself is built up of channels and plate. The haulage drums are designed to accommodate 4,500 yards of ⅞ in. diameter haulage rope.

The two 160 h.p. endless haulages are also situated in the South Pit and close to the main-and-tail haulage as will be seen from Fig. 1. These haulages run to the north and west districts of the South Pit and are also fed by the various auxiliary engines and by the 600 h.p. main-and-tail haulage. In addition, 600 tons of coal a day are dropped down an incline from the low main seam, or North Pit, and thus conveyed to the South Pit shaft. In this way the endless haulages bring to the foot of the South Shaft the full 2,000 tons output of the South Pit and 600 tons from the North Pit. One of the 160 h.p. endless haulages is illustrated in Figs. 5 and 6 above and Fig. 8 on page 808. It should be said that although these haulages are driven by 160 h.p. motors, they are rated only at 110 h.p. The arrangement of the gear is best shown in Fig. 6. As will be seen, the drums are driven by gearing from second-motion shafts, which can be driven by the two motors. This arrangement allows of one motor driving both haulages in case of emergency. The overload capacity of the motors allows this to be done for a considerable period.

The hauling drums are of cast iron, 5 ft. in diameter at the bottom of the groove, which is 5 in. wide by 2 in. deep. A brake ring is cast on one side of each

drum. The drum shaft is 8 in. in diameter and the second-motion shaft 5½ in. diameter. Each motor drives a shaft through spur gearing, in line with the second-motion shafts, the large wheels being of cast iron with machine-cut teeth and the pinions of raw hide. The pitch is 1½ in. and the spur wheels are 11 in. wide. This gearing, together with the drum gearing, is proportioned so that a speed of 580 revolutions per minute for the motor gives a rope speed of 2·37 miles an hour. The central shaft is divided in the middle, the halves being joined by a cast steel three-jaw dog clutch, the position and operating gear of which can be seen in Fig. 6. This central shaft drives the second-motion shafts through "Hele-Shaw" couplings. These are capable of transmitting 110 h.p. at 130 revolutions per minute and are operated by hand wheels and screws, as shown in Fig. 6. The final gearing to the drums consists of cast iron machine-moulded double helical spur wheels of 9 in. width and 2½ in. pitch, driven by cast steel machine-moulded pinions. The haulage gear in the North pit are generally much on the lines of those in the South Pit, and need not be described in detail. The chief difference is in the capacity of the sets, the main-and-tail haulage being of 450 h.p. and the endless haulages of 85 h.p. The mechanical equipment of the endless haulages was supplied by Messrs. M. B. Wild and Co., but that of the 450 h.p. main-and-tail haulages is by Messrs. Coulson and Co., Limited, of Spennymoor. The electrical gear in all cases was supplied by the General Electric Company.

In addition to the haulage gears, an interesting ventilation fan has also been installed at the colliery, replacing a steam-driven fan. The fan is of the "Sirocco" type, supplied by Messrs. Davidson and Co., Limited, of Belfast, and has a capacity of 500,000 cubic feet of air per minute against a water gauge of 6 in. The fan is 133 in. in diameter, the suction inlet is 148 in. in diameter, and the equivalent orifice of the mine is 82 sq. ft. The fan is driven by a 800 h.p. motor, supplied by the General Electric Company, which is fitted with a Kapp phase advancer, which maintains a power factor of practically unity. Two views of the motor are given in Figs. 9 and 10 on page 808, the exciter for the phase-advancer being well shown in Fig. 9. The phase-advancer itself is shown at the left-hand side of Fig. 2, on page 804. The apparatus on the right-hand side of the figure is the motor control gear. The motor and fan are coupled through double helical gearing fitted with forced lubrication. The gear casing can be seen in Fig. 10. The speed of the motor is 294 revolutions per minute and of the fan 198 revolutions per minute.

SHOCK TESTS AND THEIR STANDARDISATION.

*Shock Tests and Their Standardisation; Including the Effect of High Velocities on Impact up to 2,870 Ft. per Second.**

By Sir Robert Abbott Hadfield, Bart., D.Sc., D.Met., F.R.S., M.Inst.C.E., and Sidney Arthur Main, B.Sc.

In the course of their work on the Main and Sectional Committees on Notched Bar Tests appointed by the British Engineering Standards Association, the authors have contributed various experimental data and results of their research, extending over many years, with regard to the important subject of shock testing and its standardisation. The tests and analysis of the various specimens have been carried out at the research laboratory of the Hadfield Works, Sheffield.

One of the authors, in his "James Forrest" lecture, delivered on May 2, 1906, entitled "Unsolved Problems in Metallurgy," called attention to the great importance of shock tests, about which little was then known, and the value of which had hardly become recognised or appreciated. For the experiments described in that lecture mild steel of good quality was selected, containing:—

C.	Si.	S.	P.	Mn.
Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
0·12	0·02	0·02	0·02	0·28

This steel, by quenching and tempering, possessed the following mechanical properties: Elastic limit, 16 tons per square inch; tenacity, 28 tons per square inch; elongation, 35 per cent.; and reduction in area, 65 per cent. Under the Frémont notch or nick test, the test-pieces bent double cold, as was shown by the specimens then exhibited.

Portions of the same steel were heated to about 1,200 deg. C., and allowed to cool slowly. The results obtained were: Elastic limit, 9 tons per square inch; tenacity, 22 tons per square inch; elongation, 46 per cent.; reduction in area, 64 per cent.

It would naturally be assumed that with the higher elongation of 46 per cent., that is, an increase of 10 per cent., and the excellent reduction in area of 64 per cent., the material would be in as good if not in a still better condition to resist shock than the original specimen. Under the dynamic notch test the steel was found to be exceedingly brittle, snapping almost like cast-iron, and did not even bend 1 deg. Nevertheless, a test-piece of the same size and from the same material, but not nickel, under the same shock test bent double cold. This curious result shows how careful users should be in their heat treatment of steel, as without doubt brittleness can be developed under certain conditions at much lower temperatures than that used for treating the bar above-mentioned. Still more important is the clear evidence furnished that the existence of the inferior qualities of brittleness and low resistance to shock tests are not detected by the ordinary tensile tests.

Effect of Velocity of Impact.—One of the authors called attention, fourteen years ago, to the very marked effect of the velocity of impact of the falling weight or tup used in breaking overheated mild steel. A similar set of tests is shown in an appendix to this paper. This material, when tested slowly in the form of a notched Frémont specimen, bends through 131 deg. without fracture, with an expenditure of 38·5 kg.-m. (280 ft.-lb.). An exactly similar specimen tested in the Frémont shock-testing machine breaks with a crystalline fracture with an expenditure of only 1 kg.-m. (7 ft.-lb.) and a bending angle of less than 1 deg.

The velocity effect is in itself, therefore, sufficient to seriously affect comparison between the results of different types of machine; and as it is desirable, when endeavouring to detect brittle products, that the test should be as severe as possible, the authors feel confident that on the whole the Frémont test best fulfils this condition because its velocity of impact is greater.

It has been usual in this connection to take only the linear velocity of the tup as the basis of comparison. A little consideration, however, will show that the comparison should be based on angular velocity with respect to the supports. For example, in the 30 kg.-m. Charpy machine with a linear striking velocity of 5·53 m. per second, the rate of bending will be less with 60-mm. than with 30-mm. supports. The true basis of comparison should therefore be the linear velocity divided by the distance between the knife-edge and the supports or support.

The high rate of bending of the Frémont machine (or of the Guillery machine adapted for Frémont tests), in comparison with other types, is noteworthy. The large (300 kg.-m.) Charpy machine, notwithstanding its high linear striking velocity, gives by comparison a slow rate of bend—much less even than the small (30 kg.-m.) Charpy machine; this is owing to the large distance between the supports of the former.

Conclusion.—In the present state of knowledge, complete standardisation of the shock test does not seem possible, or even, perhaps, desirable. The type and characteristics of the test machine effect very considerably the results obtained, and standardisation of the machine is, therefore, necessary in certain particulars, in addition to the pattern of the test-piece; in this respect the matter is more difficult than in the tensile test, where standardisation of the form of test-piece is sufficient for practical purposes.

Much remains to be done in investigating the effect of rate of bending, dimensions of the test-piece, and other factors; meanwhile, the standardisation of the test-piece by the committee is a step in the right direction, as besides reducing the diversity of patterns in present use, the investigations above referred to will be narrowed down. It is to be hoped, therefore, that users of the shock test will support the efforts of the Standardisation Committee by adopting the suggested standard test-pieces. In many cases this will not involve any change, as the standardisation 10-mm. by 10-mm. specimen with Izod notch is already used on a considerable scale.

The authors take the opportunity of bearing testimony to the invaluable work carried out, over a long period of time and often under considerable difficulty, by the well-known French engineer, Mr. Ch. Frémont. The world is, indeed, greatly indebted to him for the foresight, ability and energy he has shown in practically originating and developing this important type of mechanical test on various materials. Mr. Frémont's work is fully set forth in a number of admirable papers by him, of which a list is given.

* Abstract of a paper read before the Institution of Civil Engineers, on Tuesday, December 14, 1920.

The Concrete Institute.—The fifth annual dinner of the Concrete Institute took place on Thursday, the 9th inst., at the Holborn Restaurant, the President of the Institute, Mr. E. Finander Etchells, A.M.Inst.C.E., A.M.I.Mech.E., occupying the chair. In proposing the toast of the Institute, Mr. J. W. Simpson, President of the Royal Institute of British Architects, referred to the development of the Concrete Institute since its inception in 1908, and mentioned that the membership now included upwards of 1,100 persons. He also congratulated the Institute and its president on their valuable work in connection with the standard notation of engineering formulæ. The notation, he said, was accepted by all Government Departments and was adopted in official documents, its use saving much time and energy in calculations. Lieutenant-Colonel H. S. Rogers, C.M.G., D.S.O., in responding to the toast of His Majesty's Forces, spoke on the subject of reinforced concrete structures in the war area of France, expressing the view that they were more difficult to destroy and more easily repaired than structures of other materials. He also gave a detailed account of the repair work carried out by the Royal Engineers on a reinforced concrete bridge, near Cambrai, which the Germans had partially destroyed. The dinner, which was a highly successful gathering in every way, was attended by about 160 members and guests, the latter including Mr. T. J. Gueritte, President of the Société des Ingénieurs Civils de France; Mr. W. B. Worthington, Vice-President of the Institution of Civil Engineers; Captain H. Riall Sankey, President of the Institution of Mechanical Engineers; Mr. C. Le Maistre, secretary of the Engineering Standards Association; Sir Alexander Gibb, of the Ministry of Transport; and several other prominent engineers, architects and Government officials.

NOTES FROM SOUTH YORKSHIRE.

Sheffield, Wednesday.

Improvements in Armaments.—At a time when new business in engineering products is scarce, the receipt of substantial orders in armaments is particularly welcome. Messrs. Vickers' contract with the Japanese Government, about which so many rumours have been in circulation, transpires to be for the supply of 7,600 tons of armour plate for the part construction of four battleships. The contract does not include, as stated elsewhere, the supply of guns and machinery. The placing of this order is in accordance with Japan's policy of naval expansion, for which an eight years' programme has been arranged. Plant which has been maintained in semi-idleness practically since the armistice will consequently be put into commission again, and staffs reinforced. The order should provide work for six to nine months ahead. It is also stated that inquiries for supplies of naval munitions are being made by Japan and the United States.

Iron and Steel.—The year is finishing tamely, both as regards production and orders. Unless an unlooked-for improvement takes place within the next fortnight, few of the big steel or engineering firms will settle down seriously to work until ten days or a fortnight after Christmas. The long list of contracts already cancelled by Colonial and foreign buyers for heavy engineering products has been considerably augmented during the past week. Order books are consequently beginning to show very thin patches. The number of inquiries in circulation for steel, machinery and tools is, however, considerable. Little doubt is felt among responsible manufacturers that as soon as prices of basic materials become more stabilised, purchases of finished goods will substantially increase. At the moment the demand for tool steel and alloy steels is restricted to immediate requirements. There is a falling-off in orders for forge work, and rolling mills could get through the required output with reduced staffs. The downward movement in prices of raw and semi-finished materials continues. Lincolnshire basic pig-iron, and Derbyshire brands, are all cheaper. Foundry iron from the latter district has been marked down to 13*l.* 10*s.*, and grey forge to 12*l.* 5*s.* Similarly, South Yorkshire bar iron makers have followed the example set by other districts and have reduced quotations 2*l.* to 2*l.* 10*s.* per ton. Common bars are now obtainable at 28*l.* 10*s.*, and best quality bars at 1*l.* more. The easing of the market with regard to special quality steels has been followed by a drop of 3*d.* to 4*d.* a pound in high-speed steel. Despite the receipt of substantial orders for railway rolling-stock and material from the Colonies, particularly India, the gross volume of work on hand is little more than half the pre-war tonnage.

South Yorkshire Coal Trade.—The advent of snow has given a fillip to orders for household fuel. Gas companies and industrial concerns are also endeavouring to build up reserves to the safety line before the Christmas stoppage. Otherwise the coal situation is quiet, and outputs at the pits are ample for requirements. If these circumstances continue and no fresh outlet for deliveries in the way of export business is found, collieries will be obliged either to organise stocks or reduce production. Quotations:—Best branch handpicked, 37*s.* 2*d.* to 38*s.* 2*d.*; Barnsley best Silkstone, 37*s.* 2*d.* to 38*s.* 2*d.*; Derbyshire best brights, 35*s.* 2*d.* to 36*s.* 2*d.*; Derbyshire house coal, 32*s.* 8*d.* to 33*s.* 2*d.*; Derbyshire best large nuts, 32*s.* 8*d.* to 33*s.* 8*d.*; Derbyshire small nuts, 31*s.* 8*d.* to 32*s.* 8*d.*; Yorkshire hards, 32*s.* 8*d.* to 33*s.* 8*d.*; Derbyshire hards, 32*s.* 8*d.* to 33*s.* 8*d.*; rough slacks, 28*s.* 2*d.* to 29*s.* 2*d.*; nutty, 27*s.* 2*d.* to 28*s.* 2*d.*; smalls, 23*s.* 2*d.* to 24*s.* 2*d.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

Middlesbrough, Wednesday.

The Cleveland Iron Trade.—The embargo on the export of Cleveland foundry pig-iron which has been in vogue since April, has been removed. The concession is welcome news, though it is of little consequence at present as there is no iron to spare for abroad, and on the other hand there is no foreign demand. The scarcity of foundry pig-iron is not quite so pronounced as it has been, but there is still very little available for early sale. Makers, however, are keen to sell ahead, but they fail to find buyers prepared to commit themselves forward to any extent at current rates. To home customers, No. 1 is 237*s.* 6*d.* and No. 3 is 225*s.* The inferior grades are very plentiful and slow of sale. Several makers still quote forge, mottled and white at the same as No. 3, but it is understood that no difficulty would be experienced in placing orders at 220*s.*

Hematite Iron.—A decidedly easier feeling prevails in the hematite branch. Both makers and merchants are offering fair parcels and are keen to sell forward, but customers are not to be tempted. There are no inquiries from abroad. For home consumption, Nos. 1, 2 and 3 East Coast brands are 260*s.*, and No. 1 is 262*s.* 6*d.*

Truck Shortage.—Once more much embarrassment is being experienced through acute truck shortage. This is a difficulty that has to be dealt with from time to time, but the present shortage of rolling-stock is said to be more pronounced than usual, and to be seriously hampering distribution.

Manufactured Iron and Steel.—No new features of moment are noticeable in finished iron and steel. Manufacturers are very busy on contracts entered into some little time ago, but new orders are not heard of. Among the principal market quotations are: Common

iron bars, 27*l.* 10*s.*; steel ship, bridge and tank plates, 24*l.* 10*s.*; steel angles, 24*l.*; steel boiler plates, 31*l.*; steel joists, 24*l.*; heavy sections of steel rails, 25*l.*; fish plates, 30*l.*; soft billets, 22*l.*; medium billets, 23*l.*; hard billets, 24*l.*; channels and flats, 24*l.* 5*s.*; rounds and squares, 26*l.* 10*s.*; black sheets, 30*l.*; and corrugated galvanised sheets, 32*l.*

Foreign Ore.—There is practically nothing passing in foreign ore. Prices are falling and consumers are not in the market to buy. The freight Bilbao-Middlesbrough is down to the parity figure of 17*s.*, which makes the ex-ship Tees value of rubio, of 50 per cent. quality, 49*s.*

Coke.—There is quite a plentiful supply of coke, and stocks are accumulating. Consumers look for lower rates, but as yet medium blast-furnace kind realises 62*s.* 9*d.* at the ovens, and quality low in phosphorus commands 65*s.* 3*d.* at the ovens.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

State of Trade.—The depression which has lately been noticeable in general trades throughout the country has gradually become more pronounced, and business is very quiet indeed. Many establishments are on short time and some are only working four days a week. The holiday season is to be of a prolonged nature this year and the usual ten days will, in some instances, be extended to a fortnight or three weeks. The generally accepted opinion is that prices having reached top level must now ease off, and buyers in consequence are not passing fresh business in the hope of securing their requirements at much lower rates than prevail at present. Broken time does not exist to any extent in the iron and steel industries on account of former heavy bookings, but the outlook for 1921 is not too bright in the meantime. Continental and American competition will have to be faced, and prices will require a lot of shading in order to secure business. Engineering establishments on the whole are not exceedingly busy, but are generally running full time.

Scotch Steel Trade.—No improvement can be noted in the state of the steel trade of Scotland, and fresh business is still very scarce. Works are being carried on steadily for the present, but it is the future which is giving some concern as buyers seem most unwilling to give out new orders until a further concession is made in prices. The latter are unchanged but are inclined to be easier. Plate mills are well employed although the Continental producers are quoting plates considerably under the home makers' rates. The demand of structural material continues very small and all works could do with orders to keep their plant going. Arrears of work in the black sheet trade are being rapidly overtaken and few orders are being booked to take their places. In the endeavour to secure more business prices have again been reduced by no less than 3*l.* 10*s.* per ton, thus making the basis price for ½ in. sheets 29*l.* per ton. The quotation for export lots has also been eased and is now round 29*l.* per ton, f.o.b. Glasgow. The dullness in general home trade is affecting all branches of the steel industry and export is also very poor at the present time. The New Year holidays are expected to extend to Tuesday, January 11, but some works may not resume until the following week.

Malleable Iron Trade.—Conditions in the West of Scotland malleable iron works show little change, and the fall in prices has not yet brought out much new business. In the different establishments employment is good, as contracts on hand are keeping the wheels running, but difficulty is being experienced in securing fresh bookings. Unless order books are substantially added to very soon the approaching holiday season may be prolonged.

Scotch Pig-Iron Trade.—The scarcity of all grades of pig-iron is still very pronounced, and although the general trade of this district is not too brisk there is an undoubted demand for pig-iron because of the smaller output. Forward business is not very heavy, and concessions in prices are being anxiously awaited by consumers. Steelmakers argue that these are absolutely necessary as the present price of hematite prevents them meeting the foreign competition. Pig-iron producers can readily dispose of their present day output, but are not unlikely to make a reduction in prices before long, so as to ensure future business. Export is very quiet.

Shipbuilding.—Work in the various shipbuilding yards is being carried on steadily, but through cancellations and an absolute scarcity of fresh contracts the outlook for the spring is far from reassuring. In some yards the position is that when the vessels at present on the stocks are launched there are no others to replace them. A report is to hand to-day of the placing of contracts for six powerful suction dredgers by the Indian Government, with the two firms in Renfrew famous for this class of craft. It is also stated that three shipbuilding firms on the lower reaches of the Clyde—Port Glasgow—which are branches of Industrials, Limited, have each received orders to build one steamer for that concern.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—The coal trade of South Wales is in a lethargic condition. There is practically no demand from abroad, and prices are irregular and generally weaker for all descriptions of coal. In fact, prices are dependent on the individual circumstances of buyer and seller. The French Bureau des Charbons has now announced the prices at which it is prepared to sanction imports for the month of January next. The new prices are f.o.b., based on 72*s.* 6*d.* for best Welsh large steam, 45*s.* for No. 1 steam smalls, and 65*s.* for block patent fuel. These figures are in case of large about 30*s.* below current market values and in respect to smalls show a reduction of about 40*s.*, and for fuel of 35*s.* per ton. Whether France will succeed in obtaining supplies of Welsh coal at these prices remains to be seen. There is, however, a strong feeling of resentment amongst local operators at what is considered the dictatorial attitude of French importers. Contrary to expectations the new prices are for the month of January only when a further revision will be made. It has also been decided that 1920 contract arrears will not be accepted after the end of the year except at the new prices. In fact, importers in many cases are refusing to take delivery of contract supplies, and as these are now freely offered to shippers, middlemen in many instances are endeavouring to dispose of them on the open market at prices which will show a profit. Thus while colliery owners refuse to take less than 100*s.* for best large and 95*s.* for Monmouthshire large, middlemen are prepared to take 5*s.* to 10*s.* less from buyers able to arrange spot loading. Inferior grade coals are abundantly offered without attracting buyers, and the cheaper descriptions of smalls have been sold down to 45*s.*, while best steam throughs command no more than 60*s.* as compared with 95*s.* and 105*s.* respectively before the strike. Patent fuel is also freely available, at anything from 85*s.*, compared with 110*s.* a couple of weeks ago, and foundry coke, though quoted at 200*s.*, is obtainable down to 150*s.* Foreign cargo exports in the past week at 354,584 tons have only been exceeded on five previous occasions in the past year. Shipments to France amounted to 190,000 tons, to Italy 56,000 tons, to South America 6,000 tons, to Spain 29,000 tons, to Portugal 4,000 tons, to Greece 6,000 tons, to British coaling depots 38,000 tons, and to other countries 25,000 tons.

The Iron and Steel Trades.—There is no improvement in the position of the tin-plate trade. There is a dearth of orders and prices continue to drop. Though some of the leading makers indicate 41*s.* 6*d.* for the basis box merchants are offering parcels down to 36*s.*, and experience difficulty in finding takers. The workers have ratified the acceptance of the sliding scale which the Tinplate Industrial Union has completed on the basis of the prices of steel bars from November last. If the ratification is confirmed it will come into operation in January. Mr. F. W. Gilbertson has been re-elected president of the Swansea Metal Exchange for the ensuing year.

THE LATE MR. ARTHUR SOPWITH.—We learn with regret of the death of Mr. Arthur Sopwith, which occurred suddenly, from heart failure, on Monday last at the Old Vicarage, Chasetown. Mr. Sopwith, who was in his 78th year, was appointed to the management of the Cannock Chase Collieries in 1873, and afterwards became general manager. He was a member of the Institution of Civil Engineers and a Fellow of the Geological Society, and he acted as president of the South Staffordshire and East Worcestershire Institute of Mining Engineers in 1884. His public work included serving as a member of the Royal Commission on Coal Supplies which sat from 1901 to 1904, and in addition to his wide interests in the mining industry of the Midlands, he was prominently associated with county and local affairs. Mr. Sopwith retired in 1907.

PERSONAL.—Mr. W. M. Ratcliffe, general manager of the well-known firm of Heenan and Froude, Limited, general engineering manufacturers, Worcester, has recently been appointed a director of the company.—Mr. A. H. Darker, chief engineer and manager of the Electrical Department of J. Stone and Co., Limited, Deptford, has now returned to London, after concluding a business tour round the world, occupying some two years and nine months.—The Standard Engineering Company, Limited, Leicester, and Oswald Stott, Limited, Birmingham, have amalgamated their interests in fan work and fan installations under the title of "Standard and Oswald Stott (Engineers), Limited," Evington Valley-road, Leicester.—Mr. W. H. Purnell, who has been associated with the firm of Herbert Morris, Limited, Loughborough, for upwards of twenty years, has been appointed vice-chairman of the company.—Members of King's College Engineering Society visited, on Wednesday, the 8th inst., the works of Automatic and Electric Furnaces, Limited, 281 to 289, Gray's Inn-road, and witnessed demonstrations of the Wild-Barfield automatic steel-hardening furnaces.—We are asked to state that the business of the late Mr. Edward Hayes, at Stony Stratford, is being carried on under the name of Messrs. Edward Hayes, Limited, by Mr. E. H. Littledale, A.M.Inst.C.E., who has for long been connected with the firm, being managing director.—Messrs. Stothert and Pitt, Limited, Bath, inform us that they have arranged to be represented on the North-East Coast by Mr. Wilson S. Carr, M.I.Mech.E., M.I.E.E., whose offices are at Victoria Buildings, Grainger-street, West, Newcastle-upon-Tyne.—Sir John Cowan, D.L., chairman of directors of Messrs. Redpath, Brown and Co., Limited, was entertained to dinner recently by the Edinburgh workmen and staff and presented with an address on the completion of his sixty years' service with the firm. Sir John joined the firm on September 3, 1860, and in 1868 he became a partner in the concern. The firm had begun in a very small way with 12 employees; now they had 1,200. They have had a prosperous year and the share of profits payable to the employees will be increased from 5*s.* to 6*s.* per week for men, and from 2*s.* 6*d.* to 3*s.* per week for boys. The presentation of the address was made by an employee who had been with the firm for forty-four years, and the whole occasion betokens the excellent relations existing inside the concern.

NOTICE OF MEETING.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, December 17, at 6 p.m., "Thermodynamic Cycles in Relation to the Design and Future Development of Internal-Combustion Motors," by Dr. William J. Walker, of Manchester.

FRACTURE OF BOILER-FEED VALVES.—Some peculiar cases of fracture of boiler-feed valves, which recently occurred in a large plant in Bavaria, are briefly mentioned in the *Zeitschrift Vereines Deutscher Ingenieure* of November 13. In two cases, which followed one another at a short interval, the valve cases were torn open so that large quantities of water and steam escaped; the rent was, in one case, 400 mm. (16 in.) long. The material and fixing were found satisfactory, and the explanation suggested is water hammer.

LLOYD'S REGISTER OF SHIPPING.—Many of our readers will learn with regret that Sir Thomas L. Devitt, Bart., the chairman of Lloyd's Register, has found himself compelled by failing health to retire from that office. Sir Thomas's connection with the administration of Lloyd's Register has extended over a period of twenty-seven years, since he became a member of the Committee in 1893. In 1907 he was elected chairman of the Sub-Committees on Classification, and he has held the office of chairman of the General Committee since 1909. His occupancy of the chair has thus covered most eventful years, including the whole period of the war, during which he has rendered eminent services, not only to the Society, but to the great shipping and mercantile interests which it represents.

COMMERCIAL AVIATION IN AUSTRALIA.—A lecture entitled "The Possibilities of Aviation in the Dominions" was delivered before the Institution of Aeronautical Engineers on Wednesday last, by Mr. Hector Sleeman, managing director of Aerial Transport, Limited (Australia). The lecturer pointed out that in this country the conditions for commercial aviation were by no means ideal owing to adverse weather, the competition of existing means of transport, the small distances between important centres and the conservatism of the population, but that in most of the Dominions the conditions, in these respects, were more favourable. He confined his remarks however, to the Australian Continent, and mentioned that the best route from a flying point of view would be between Melbourne and Adelaide, but explained that the time saved on it would be little, or nothing, without night flying, and that the available loads would be less and would fluctuate more than on other routes. The Melbourne-Hobart route, on the other hand, would offer exceptionally good loading and would enable a saving in time of 21 hours to be made on a journey of 430 miles.

GAS TURBINES.—At a meeting of the Barrow and District Association of Engineers, held on Friday, December 10, Mr. C. E. Beardmore read a paper on "The Problem of the Gas Turbine." He said that there was no immediate prospect of gas turbines becoming a commercial success, and added, the only ones so far experimented with, that had shown any prospect of success, depended a good deal on the addition of steam to the gases. This was the case with the Armengand and Lemale turbine. Here the combustion chamber was lined with carborundum, and the nozzle was kept at a working temperature by means of a water jacket. The water, after being heated in the jacket, passed into a flash boiler, and the steam generated gave additional power and tended to keep the blades from being overheated. The excessively high temperature, combined with the action of the steam, caused rapid corrosion of the blades. The latest Lemale gas turbine was intended to yield 300 h.p. The efficiency of the compressor was estimated at 65 per cent., and it was claimed that the turbine was supposed to have generated twice the power required to drive the compressor. The speaker thought the results could not be so good unless a large amount of steam were used.

THE INSTITUTE OF TRANSPORT.—The second lecture arranged for graduates and students by the Institute of Transport was delivered on Friday last by Mr. Ashton Davies, M.B.E., superintendent of the line of the Lancashire and Yorkshire Railway. This lecture was concerned with the constructional requirements of railways from an operating point of view, and systems of control. Mr. Davies first gave a review of signalling practice, and discussed the way in which it affected operations, dealing in turn with home signals, starting and advance starting signals, signals for shunting movements, electrical repeaters, and route-indicating signals. This part of the subject was completed by a discussion of block telegraph regulations, terminal and station yard working, permissive block working and working in both directions over one line. The lecturer then passed to track circuiting, interlocking block, semi-automatic and automatic signalling and power signalling, closing with track block installations. The second section of the lecture dealt with lay-outs which was not discussed at length, and then the lecturer passed to systems of traffic control and discussed the advantages of these, dealing naturally at some length with the system in use on his own line. This we consider was one of the most successful parts of the lecture, the advantages being presented in a very succinct form, and the requirements of the system also being set forth very clearly, with the details of staff duty, &c.

ELECTRICAL PLANT AT THE EASINGTON COLLIERY.

MESSRS. THE GENERAL ELECTRIC COMPANY, LIMITED, ENGINEERS, LONDON.

(*For Description, see Page* 804.)

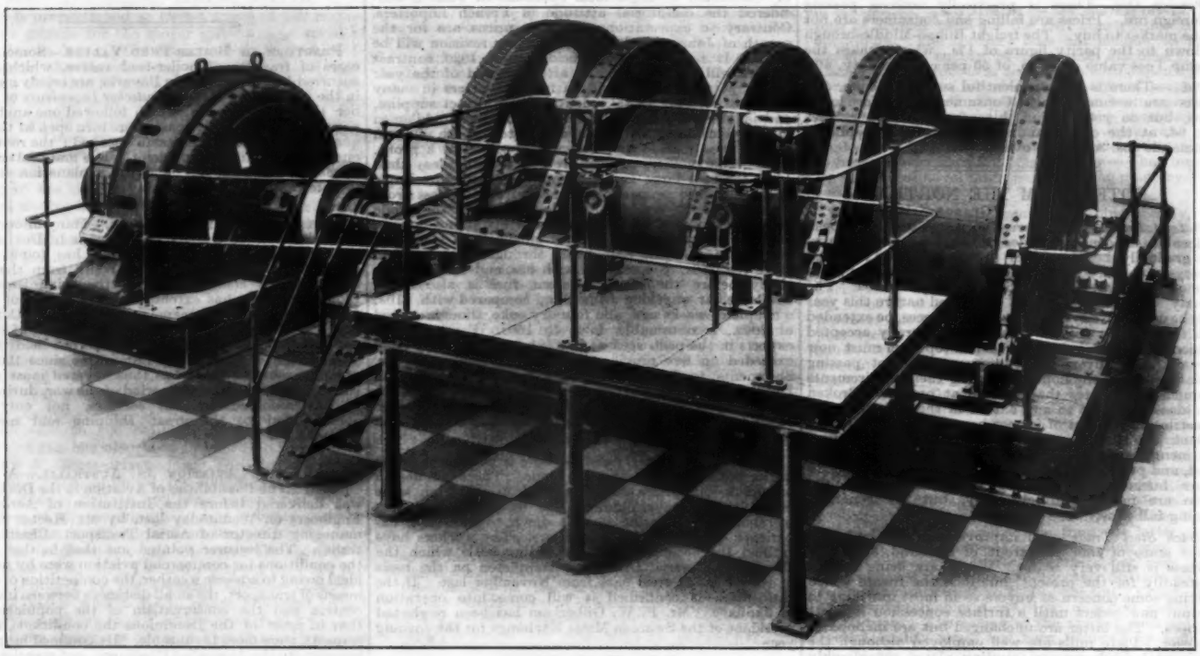


Fig. 7. General View of 600-H.P. 'Main-and-Tail' Haulage.

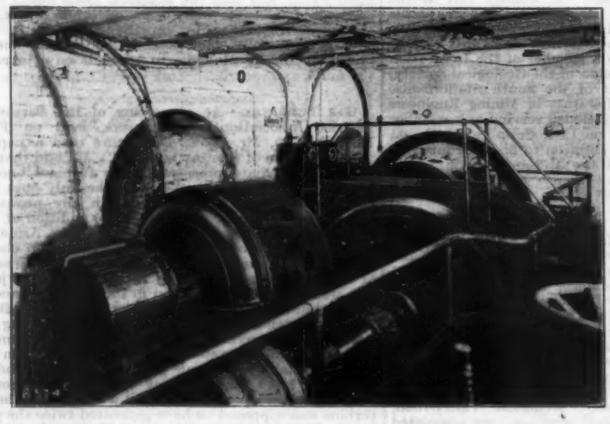


Fig. 8. 160-H.P. Endless Haulage.

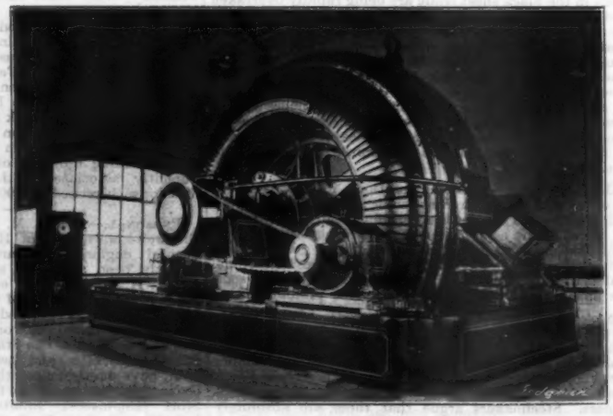


Fig. 9. Fan Motor showing Exciter for Phase-Advancer.

Fig. 10. 800-H.P. Fan Motor with Gearing.

2,250-LB. FOUR-STAGE ENGINE-DRIVEN GAS COMPRESSOR.

CONSTRUCTED BY MESSRS. PETER BROTHERHOOD, LIMITED, ENGINEERS, PETERBOROUGH.

(*For Description, see Page 800.*)

Fig. 4.

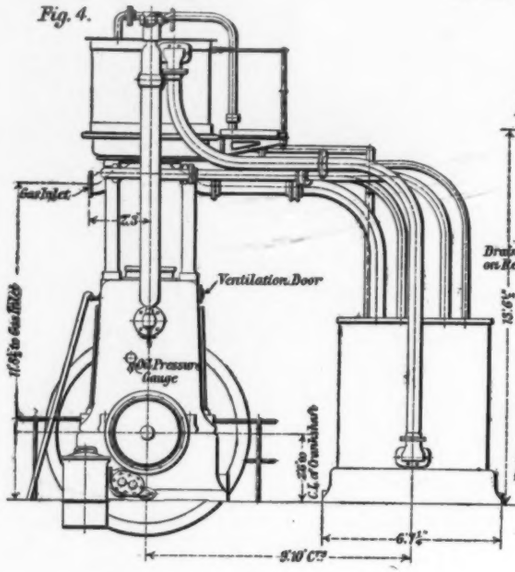


Fig. 1.

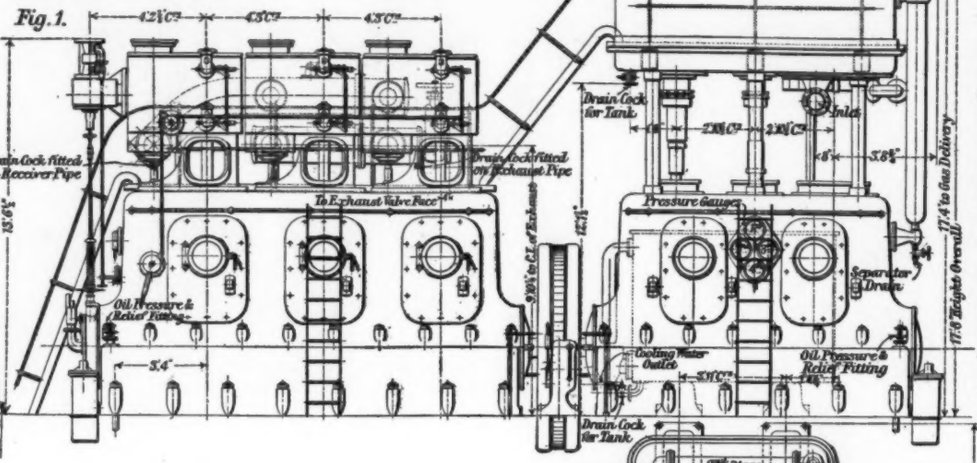
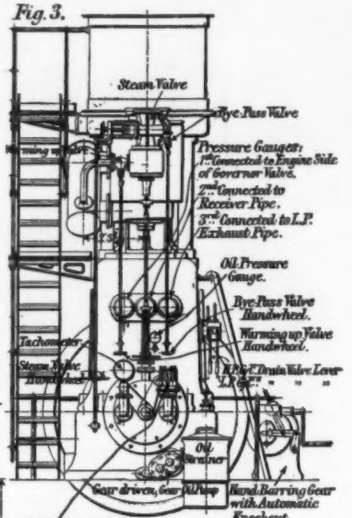


Fig. 3.



Cylinder Lubricator

1st Lead to Engine Side of Governor Valve.
2nd Lead to Inlet Side of 1st L.P. Cylinder.
3rd Lead to Inlet Side of 2nd L.P. Cylinder.

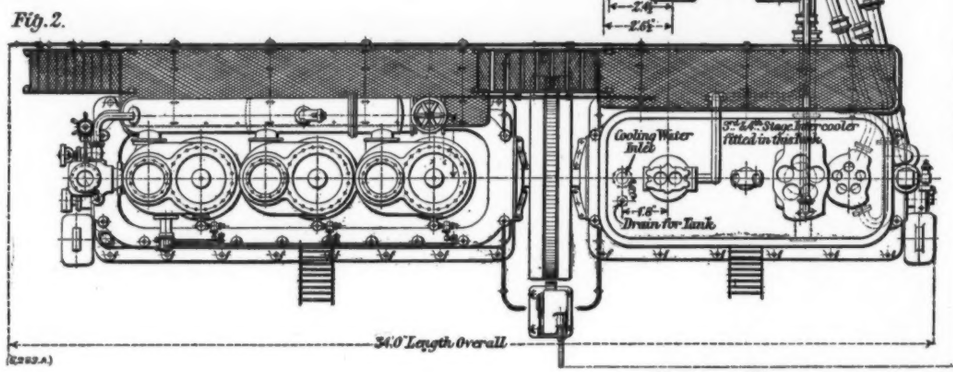
COMPRESSOR—

R.P.M.	200
STAGES...	FOUR.
DELIVERY PRESSURE	2,250 LB. PER SQ. IN.
CAPACITY	1,000 CUB. FT. OF FREE GAS PER MIN.

ENGINE—

WORKING PRESSURE	150 LB. PER SQ. IN.
BACK PRESSURE ...	10 LB. PER SQ. IN.
B.H.P.	650

Fig. 2.



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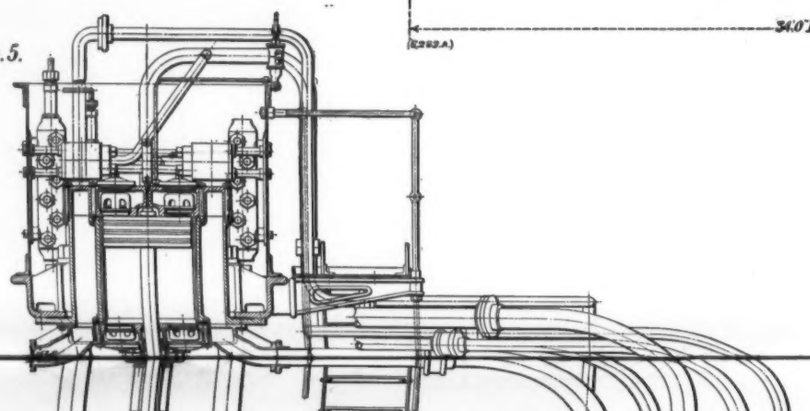
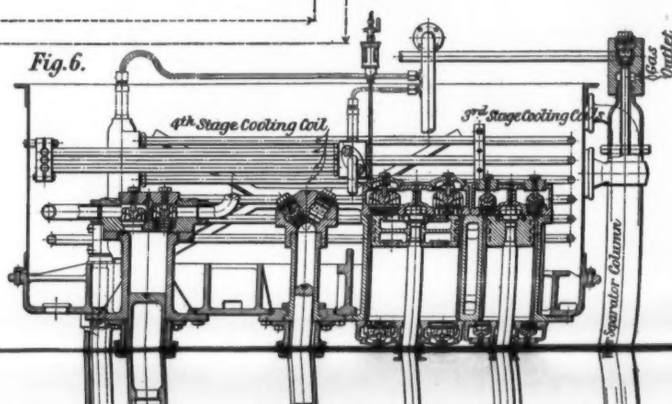


Fig. 6.



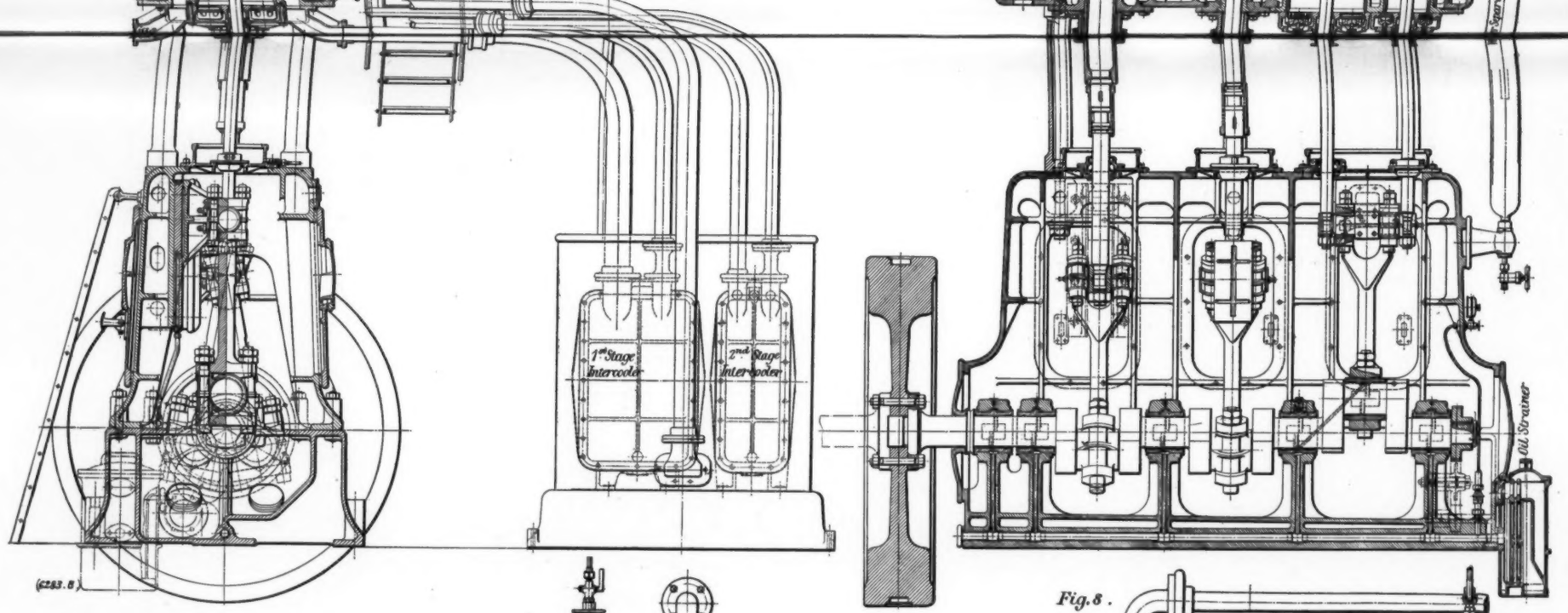

1st Stage Intercooler
2nd Stage Intercooler
Oil Strainer
(G283.B.)

Fig.7.

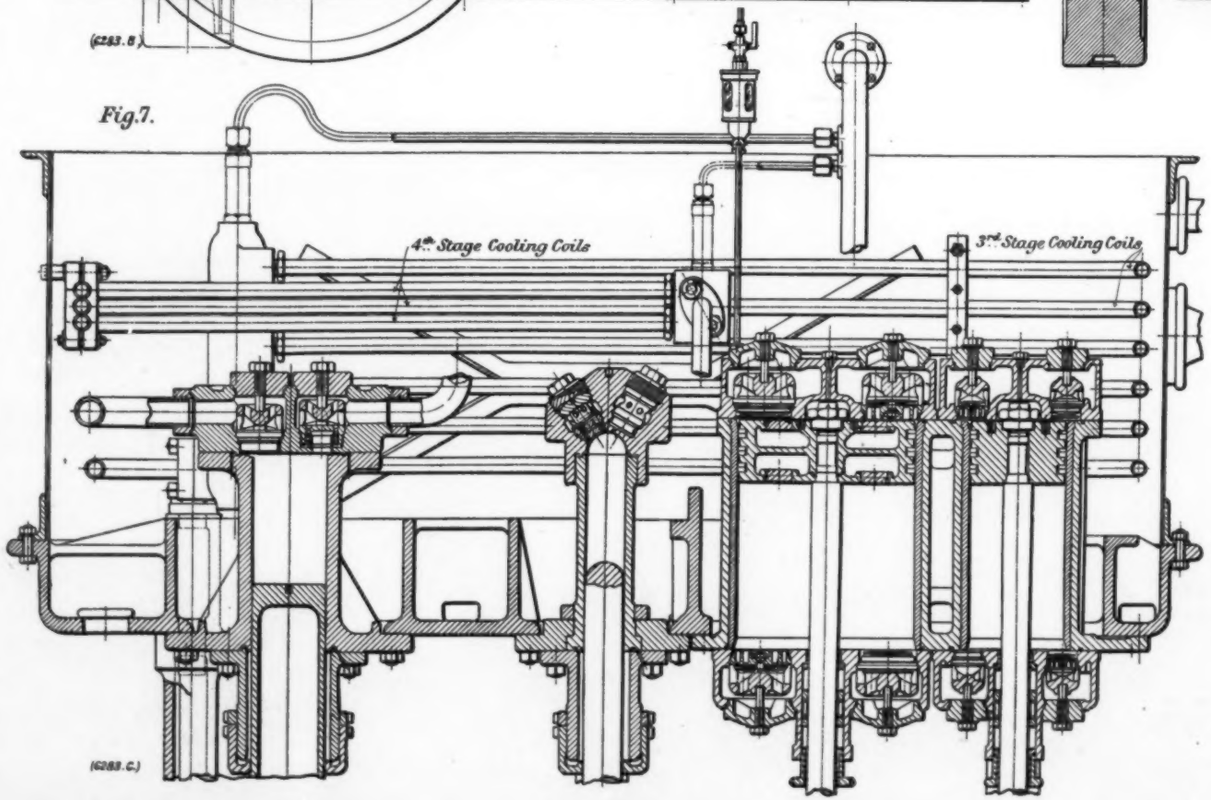
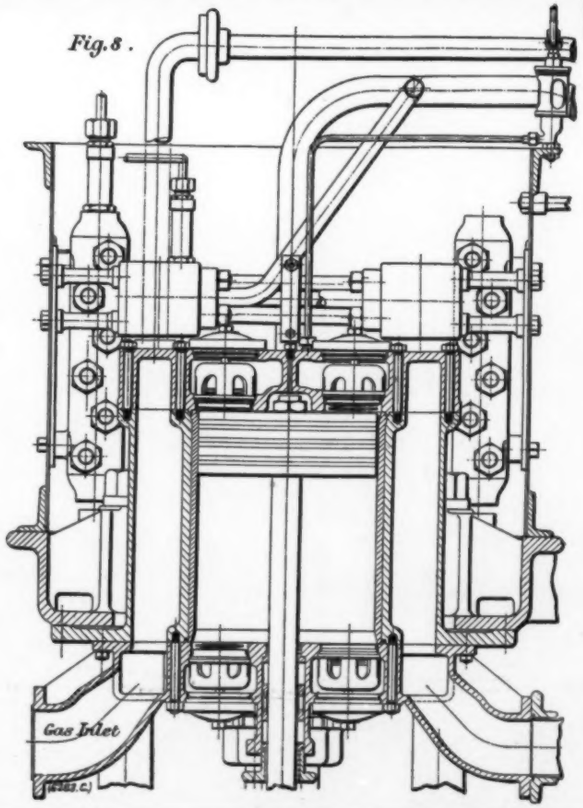

4th Stage Cooling Coils
3rd Stage Cooling Coils
(G283.C.)

Fig.8.


Gas Inlet
(G283.C.)

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ADVERTISEMENT RATES.

The charge for advertisements classified under the Headings of Appointments Open, Situations Wanted, Tenders, &c., is four shillings for the first four lines or under, and one shilling per line up to one inch. The line averages seven words. When an advertisement measures an inch or more the charge is 12s. per inch. Payment must accompany all orders for single advertisements, otherwise their insertion cannot be guaranteed. Terms for displayed advertisements on the wrapper and on the inside pages may be obtained on application. The pages are 12 in. deep and 9 in. wide, divisible into four columns of 2¼ in. in width. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received on the Friday previous to the day of publication.

SUBSCRIPTIONS, HOME AND FOREIGN.

REVISED RATES.

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For Canada—	
Thin paper copies	£2 18 6
Thick ,, ,,	£3 3 0
For all other places abroad—	
Thin paper copies	£3 3 0
Thick ,, ,,	£3 7 6

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TELEPHONE NUMBERS—3063 and 8568 GERRARD.

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With a Two-Page Plate of a 2250-I.H. FOUR-STAGE ENGINE-DRIVEN GAS COMPRESSOR.

NOTICE.

A few months ago the Proprietors of "ENGINEERING" were compelled to advance the price of this Journal to 1s. per copy, owing to the enormous increases in the cost of paper, engravings and printing, &c. Now higher transport and delivery charges involve a further increase to 1s 2d. per copy, and this price dated from and included the issue of Friday, April 2, 1920. As the postal rates have been again increased, the price of single copies sent by inland post is now 1s. 2½d.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions still imposed by the Government on the importation of paper and the consequent shortage of Supplies, Newsagents will not have copies for chance customers; therefore readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk.

NOTICES OF MEETINGS.

Notices of Meetings to take place during the present and next week will be found on page 807.

ENGINEERING.

FRIDAY, DECEMBER 17, 1920.

THE NAVAL SITUATION.

THE Government have acted wisely in referring the present naval situation to the Committee of Defence, as the problems which have arisen as a consequence of war experience are of the first magnitude, and can only be solved by the closest investigation alike from the strategical and tactical standpoints and from the constructional point of view on the fullest scientific basis. It was natural that controversy should arise not only as regards the will of the Government to maintain our naval supremacy, but also as to the most suitable type of ship calculated to secure this end. That the United States is building sixteen capital ships and Japan eight of designs which must more or less embody the lessons discovered in the war, while we have not a single new ship on hand, capital or otherwise, gives, as the French say, "furiously to think."

Controversy, however, whether on the platform, in the press or in Parliament, seldom produces satisfactory results, except by acting as a stimulant to thought, because those engaged are often too prone to make points against those who do not see eye to eye with them rather than to elucidate with conscientious earnestness of purpose the problems under review. It can scarcely be said that the discussion which has been going on recently with regard to the present naval situation is free from this serious blemish, so that the removal of consideration to the calmer and more judicial atmosphere of the Committee of Defence is acceptable. This is especially the case as all able to contribute towards a solution will under these circumstances have the privilege of expounding their views before the committee, with full confidence that due weight will be given to them.

There has been some measure of confusion of thought as to whether the Committee of Defence is the most appropriate tribunal before which the issue should be brought. It has been contended, for instance, that a committee composed of naval officers shipbuilders, engineers and scientists corresponding to that appointed by Lord Fisher to evolve the elements of the Dreadnought design, would have been more appropriate. But in that instance there was no uncertainty as to the type of fighting ships aimed at. Lord Fisher's desire was to produce "an all big gun ship" with the other requisites to efficiency based on the most satisfactory compromise, and obviously this involved constructional questions of great importance. To-day the primary problem is one which in the first instance, at all events, is concerned with the type of ship. Once more the question is surface ship or submarine, perhaps even restricted to battleship or submarine.

Years ago the French, who had done more in the initial stages of submarine boat design, were faced with this problem, and for a time at least they were certainly disposed to place greater reliance on the submarine than on the battleship. It is no disparagement to our present relationship with our allies to-day to recall that their submarine programme was then, in the early years of the century, regarded as a menace to the British merchant service. Indeed, Commander Sir Trevor Dawson then foreshadowed what became a reality in 1917 by picturing the tremendous hazard of a fleet of submarines along the highways of commerce into and out of British ports. [Parenthetically it may be asked if we ought not to have been better prepared with weapons against submarines.] The French ultimately returned to adherence to surface ships, including capital ships, while maintaining the building of submarine craft.

It is true also that prior to the war there were strong advocates amongst experienced British naval officers for the supercession of battleships and battle cruisers by submarines, and many predictions were made as to the impotence of these capital ships in the event of war with a great European naval power. None of these predictions was fulfilled. We were told that we would require to bottle up our great battle squadrons in harbour. It is even said now that such fleets while in Scapa Flow ought to have been sunk by the German submarines. No attempt was made to do this, although the advocates of the submarine admit that the conditions were admirably suitable for such a great achievement.

Why was this prediction not fulfilled? The Committee of Defence will be expected to consider this. Far from the fighting fleets of Britain being confined to their harbours, Lord Jellicoe, in his flagship, led his fleet in the first sixteen months of the war alone on cruisers seeking for the enemy fleet over a distance of 44,680 miles, and Lord Beatty in subsequent cruises covered equal distances, and yet not a single battleship was sunk by submarines. It is true that several of the older ships were so disposed of early in the war by the Germans, but this was largely due to their lack of speed, so that the question of design and construction of surface ships to combat torpedo attack from submarines becomes one of the problems to be tackled by the Committee of Defence in their investigation, and to this we shall refer presently.

Again, at the Battle of Jutland, no German submarine was engaged, and from German accounts we learn that over 100 torpedoes were fired by surface ships, but the only battleship hit was the Marlborough, and by reason primarily of the admirable system of "bulge" protection she was able to return safely to the base. It can scarcely be said that the Battle of Jutland was fought to a finish owing to conditions of invisibility intervening, or more might have been learned as to the power or impotence of the battleship. At the same time the fact remains that as a result of the battle the German fleet never again left its base.

A contention of the advocates of abolishing the battleship is that a main function of the navy is the protection of our overseas commerce and no one will controvert this view. This involves the destruction of the enemy fleet, however it may be composed. The Emden had more British merchant ships to her credit than any one submarine; the same can be said of some of the specially-adapted merchant ships of the German fleet. Without surface ships these marauding cruisers could not have been combatted. It is difficult, too, to reconcile the supercession of surface ships with the triumph at the Falkland Islands, which had immense influence on the issue of the war and on the safety of merchant shipping on distant seas.

There is, however, much to be said in favour of the submarine because of its success in torpedoing merchant ships in the narrow seas. Certainly the results during the period when there was unrestricted submarine attack between April and June of 1917, had a most disturbing effect upon the *morale* of the British people. In these three months 377 merchant ships of a gross tonnage of about 1,228,000 tons were sunk with a loss of life of nearly 2,000. This gave some credence to the view that the German submarine policy might ultimately succeed. But this promise was short-lived. On the one hand it may be that Germany could not maintain the submarine fleet at adequate strength. We now know that Germany began the war with 28 submarines, the two largest being of

675 tons with six torpedoes, that she completed three before the end of 1914; that in 1915 sixty-two were delivered, in 1916 ninety-five, the size having increased to 860 tons, in 1917 one hundred and thirty, the largest being 1,500 tons, and in 1918, up to the armistice, eighty-one, the largest being 2,158 tons. Thus they brought into action from first to last 399 submarines. There were sunk by British warships and auxiliaries 207 German submarines, and it is interesting to note that the number of losses in each succeeding year was progressive: Thus for the first five months of the war in 1914 the losses were five, in 1915 twenty, in 1916 thirty, in 1917 seventy-two, and in 1918, up to the time of the armistice, eighty. The increase in the destruction of German submarines beginning in 1917 was due to the splendid work done by scientists in devising means to combat the unrestricted attack by the Germans on our merchant fleet.

It is not necessary here to enter at large upon the work thus done for the protection of merchant ships, in the construction of special types of attacking craft, in the discovery of hydrophones for the location of submarines and in the design of depth charges and other weapons for destroying them. The influence of such means and the possibility of improving and augmenting them are subject-matters for the consideration of the Committee of Defence. The effect of these instruments of destruction is found in the fact that the losses of British merchant ships due to submarine attack greatly diminished, the numbers per month in the summer of 1918 being reduced to about 40 ships, as compared with 125 per month in the period of most intense submarine attack. In part this was due no doubt to the effect on the *morale* of the crews of German submarines, an effect which largely led to the revolution amongst the *personnel* of the German Navy. This may not be a factor which should influence the decision of the Committee of Defence, but serious consideration must be given to the potentialities of counter-attack on submarines.

On the other hand, equal care must be given to what may almost be regarded as inherent difficulties in the design of submarine boats. The Germans at the time of the armistice had ordered 400 new submarines—in itself a proof that they had still confidence in this style of craft—but an examination of the boats surrendered by the enemy to Britain showed that little progress had been made towards advance in design and particularly in propelling machinery.* It is to the credit of the British service and engineers that we had the fastest submarines on the surface as well as submerged. It is not possible to combine these advantages in one craft and, moreover, the fast surface vessels of the "K" class had an exceptional combination of machinery—geared turbines, electric generators and motors, and oil engines—and consequently great weight resulted. Even in the vessels with internal-combustion engines and electric machinery the weight was unavoidably high, and consideration will require to be given to the problem as to whether it is possible to achieve better results in weight per unit of power developed. It is gratifying to know that the engineering laboratory of the Admiralty has been extended, and any expenditure in this direction will be most profitably incurred. The four-cycle single-acting engine is the most largely favoured, but the desire of the engineer is for a satisfactory workable type of two-cycle double-acting engine, and it will be well if the attention of the engineering laboratory of the Navy is directed towards the production of such a prime mover not only for submarines but for other types of craft. The Admiralty can be assured of the encouragement and assistance of private firms who have done much in this country for the development of the internal-combustion engine. Another inherent difficulty of the submarine is that increased size involves greater time in diving, which is the preferable system of submergence when the vessel is under way; and in action the chances are that this will be the prevailing procedure. As the submarine grows larger, too, the effect of shallow water becomes more and more serious, so that before reliance can be placed on the submarine as the sole or principal unit of a navy for attacking or defending commerce many scientific problems must be solved.

With the capital ship, on the other hand, improvements can be effected in practically every element in design. It is no stretch of imagination to assume that since the war those responsible for design at the Admiralty have been giving full and continuous consideration to all these problems. During the war, amazing developments were made and the skill and experience of the naval architects, engineers, ordnance and torpedo officers were proved by the successes recorded.

We have referred to the improved protection against torpedo attack, and it need only be mentioned also that the dropping of bombs by aircraft was combatted by increased horizontal protection. Thus even the new arm of the service may be checkmated as far as the capital ship is concerned, but it will be a powerful factor against the submarine. The whole question of the possibilities of aircraft will have to be considered from the strategic and tactical points of view, and it would seem as if a serious error had been made from the administrative point of view in allowing the new arm of the service to pass absolutely from Admiralty control. It is of the utmost importance that research work should continue in connection with the constructional features of all types of aircraft.

All this may seem to justify the view that a special committee should have been appointed to consider the question rather than that it should have been left to the Committee of Defence, but there is the old saying about doctors differing. Apart from this the Committee of Defence is not by any means, as is so often assumed, a body composed of politicians. On the contrary, there is included the First Lord of the Admiralty, the First Sea Lord and the Director of Naval Intelligence, while the Committee have the power to co-opt anyone as a member. Moreover, they will have at their disposal the fullest possible information from the Admiralty, and no one knows better the facts of war experience. It can be assumed that the naval staff have already analysed with this full knowledge all that can throw light upon the selection of the most desirable warships for the future. Everyone with views backed by experience will be welcomed before the Committee, and when a decision is arrived at as to the type or types of craft desirable for fulfilling the vital work of Empire defence, it will be for the scientist, the naval architect, the engineer and other experts to embody in such ships the best that technical knowledge can devise. The one thing essential is that there shall be no heroics. Safety must come first.

* See Engineering, vol. cvii, page 763.

ROADS AND RAILWAYS.

The Ministry of Transport appears for the moment to be steering a course through very troubled waters. Only a few days after it had itself launched a scheme for utilising the tidal power of the Severn estuary, the Water Power Resources Committee of the Board of Trade, whose work it really is to examine these things, has been unkind enough to say that it has been strongly impressed by the extravagant ideas current on this subject, and that most of the suggestions which had come to its notice showed no recognition of the very serious technical difficulties involved. Two schemes, it states, impressed them favourably, but neither, be it noted, happens to be the one the Minister of Transport brought out on the plea that he wanted a bridge across the Severn. This makes the situation all the more extraordinary, for clearly if this Ministry had any right to spend public money on such investigations it should be somebody's business to see that the Water Resources Committee is kept informed of everything of the kind being done.

There is the other possibility, of course, that the scheme backed by Sir Eric Geddes has been examined and turned down. The Water Resources Committee's report quite honestly recounts the difficulties of the proposition and suggests the appointment of a technical commission. We sincerely hope that before the country is committed to the huge expenditure involved in the execution of the Severn estuary scheme a very strong commission will go thoroughly into the matter, and that the question whether or not a work of such magnitude should be undertaken will not be left to the decision of a bureaucratic Government department.

While this enterprise of the Ministry is for the moment scotched the last week has seen published the considered reply of the railway companies to the Ministry's idea of railway control as propounded by Sir Eric Geddes in June last. At the time we considered that the plans had been put forward in an incomplete form. The Minister may have been compelled by circumstances of which we are ignorant, to make some statement before he was really prepared to do so. We give him the benefit of this possibility. In some ways the scheme appeared to be a hasty copy of legislation introduced in the United States, of which Sir Eric would seem to be a strong admirer. The rough scheme then sketched out has not appealed to the railways more than it did to us, and in the memorandum issued this week they criticise it clause by clause. The Federation of British Industries has also issued a statement on the subject which, though naturally not coinciding with the railway companies' views, yet strongly dissents from many, if not most, of the Ministry's proposals.

The point on which there is least disagreement in principle seems to be that of grouping, which, of course, the railways had endeavoured to introduce themselves, before the war, but failed. But the grouping approved by the railways, and that suggested by Sir Eric Geddes differ very considerably. Under the Geddes scheme the North-Eastern and Hull and Barnsley companies, for some reason, were placed in a group apart. The companies (the North-Eastern and the Hull and Barnsley dissenting) propose that this separate group should disappear. Clearly this is not to the liking of the North-Eastern Railway, any more than some of Sir Eric Geddes' suggestions have been to others. The appointment of Mr. Arthur Watson, of the Lancashire and Yorkshire Railway (an engineer we are pleased to note) to the joint managership of that line and the London and North-Western, seems to indicate that closer relations are coming into being voluntarily among the railways, and this means that the ultimate transition to groups will be rendered a good deal easier.

We have frequently argued in these columns against the waste of unlimited competition, whatever the service it resulted in. If we could strike the happy mean of healthy competition without waste we would clearly make our money go further. But we would rather see the old system revived than too much control, especially when the latter is biased by a desire to regulate without responsibility for the results. Speaking at the Institute of Transport on Monday last, Lord Montagu of Beaulieu said we were in danger of becoming too much administered in the matter of transport. The national genius, he said, lay in the minimum of interference by Government departments, and thoughtful foreigners had concluded that one of the greatest merits of our political institutions was in the elasticity which came from the comparative absence of official interference. Lord Montagu spoke with special reference to motors and roads—in which direction we are only on the very threshold of official control. There is, however, even now a large section of the motor transport industry which views with misgivings what is happening to the railways to-day. To-day it is the railways; to-morrow it may be the motor transport industry.

Sir Eric is ostensibly working at the moment for the extension of the latter. To encourage it everything possible is being done to improve the roads, and to make special arterial roads, cut-offs and so on, even to the employment of otherwise unemployed on the work—using, of course, the public funds. Although the motor industry will be taxed for road purposes, it is nevertheless being subsidised by the country to a large degree in this manner. The railways never had their roads provided for them, and in addition are heavily muleted in rates in any town to which they bring advantages.

Now the railways have always been looked upon as virtually a public service, and, having hitherto had practically a monopoly, except of course in the case of the flourishing pre-war coastwise trade, it was logical to control them to some extent. This

position was accepted by the railways themselves. Even in those days the control of rates latterly showed a tendency to expand into interference in other directions, as, for instance, wages settlements, but now the plan is to regulate everything, even to the profits of the shareholder. Rates, it goes almost without saying, are to remain subject to control, and the Minister himself is to be able to refuse to put the rate revision machinery into motion. Wages are to be regulated by a national board; the raising of capital is to be regulated; the standard of equipment is to be regulated; the Ministry is to be able to insist on what it considers adequate service and facilities being given, and to require capital expenditure, and so on and so forth. And after the shareholder has received not more than a regulated return the rest will be spent some other way according to the dictates of the State. And with all this the Minister of Transport undertakes no financial responsibility whatever to the shareholders, an attitude which the companies not unnaturally regard as decidedly one-sided.

All the suggestions above named are based on what Sir Eric calls the "charter" of the companies, but the latter quite justly regard them as restrictions upon their charging powers. We have often pointed out that the railways sell transport like any trading concern, and should be allowed to make a fair profit, the regulation of rates being easily adjustable to this end. It does nor appear to us quite fair that this restriction, now compared with other industrial undertakings a heavy handicap, should be claimed by the State to constitute a concession for which it is entitled to impose all the other burdens Sir Eric Geddes now seeks to impose upon them.

But this is nothing like the whole situation, Regulation of the railways was founded on the fact that they were practically monopoly holders. That position no longer holds good. Road services are developing to an extraordinary extent, and are to-day in active competition for much of the railway traffic, and it this industry develops as its supporters hope it will, and we hope it may, before long it wil become a very important service in the country. Now this will have been built up, although taxed, largely on the road subsidy from the State, while the railways are to be required to spend capital just as the Minister of Transport for the time being thinks fit on their own or on new permanent-way, &c. The motor services, too, are to be free to charge what they like or can, while the railways are to be strictly limited in this direction. This is not equitable. It is rather surprising that the Federation of British Industries also ignore this competitive traffic in their attitude towards the railways. They are quite content to see the railway shareholders' returns limited by the State, and demand that any surplus be allocated to the reduction of rates. This sounds very well, but we hear quite another story if the State tries to alleviate the national financial burdens by limiting manufacturers profits. There, we are told, all restriction is wrong.

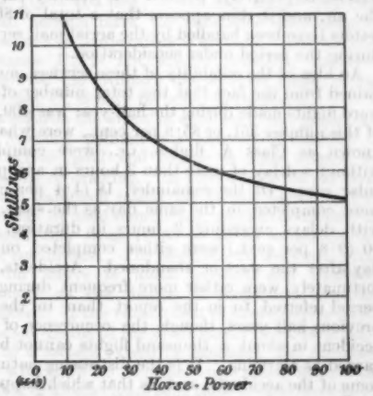
The logical conclusions appear to be that if the railways are to be regulated, and if we are to make roads for the motor services to use for their profit, the latter concerns should be regulated too, as to charges, facilities, services, the raising and expenditure of capital, and so on. It is quite possible Sir Eric Geddes has this ultimate object in view, but it will, we are afraid, lead to a vast amount of trouble, and an enormous increase in his department, if this is to be brought about. On the other hand, if the motor developments continue, and it must be conceded that in many directions motor transport offers peculiar attractions, the erstwhile monopoly of the railways will largely disappear as a result of this new competition. The natural consequence would be, in any saner times than the present, to consider this competition as offering in itself considerable safeguards, and to relax, therefore, a good deal of the detail control which Sir Eric thinks fit to saddle the railways with now. As this would tend to reduce this Ministry to dimensions somewhat more comparable with the rest we are afraid that such a state is hopeless to look for during the present *regime*.

MOTOR TAXATION.

WE have on several occasions called attention to the inconsistencies of motor taxation under the Treasury rating. The fact that the new scale of taxes comes into operation on January 1, 1921, emphasises these inequalities. Under the old scheme the tax on the cars was at all events a moderate one, and the glaring inconsistencies of the rating were to some extent covered by the fact that the tax was not a flat rate per horse-power but increased with the rated power of the engine. Further, the motorist paid the greater part of his tax in the form of a tax on petrol, and this was an absolutely fair and equitable tax in every way.

In the new scheme of taxation, the petrol tax is dropped and the whole sum is raised by taxes on the cars themselves, the scheme of taxation being varied according to the use to which the vehicle is put and the number of its wheels. Thus pleasure vehicles are taxed differently according to whether they have two or three wheels on the one hand or four on the other, the taxation of the two and three-wheeled vehicles under 8 cwt. being by weight and that of the four-wheeled by horse-power of the engines estimated according to the Treasury rating. Hackney carriages are taxed according to their seating capacity, while trade vehicles of practically all other kinds are taxed according to their weights.

We shall have something to say later as to the anomalies introduced by these various systems of taxation and their probable evil effects on trade, but for the moment we will deal with the influence



of the Treasury rating on the ordinary pleasure car. Two points must be borne in mind in considering this rating. Firstly, it has been definitely proved by the racing of cars in public contests that the maximum possible power of a specially-designed engine is proportionate to the cubic capacity of the cylinders and not to the area of the pistons. Secondly, it has been proved that an engine running at a moderate speed can be built considerably lighter per actual maintained horse-power than the extreme high-speed type.

Both these facts are what would be expected from theoretical considerations, and experience has proved that in both cases the theoretical considerations apply in practice. From these facts it is easy to see the effects will be the Treasury rating of horse-power, which is based solely on the piston area.

In the first place it is obvious that where the engines are all constructed to develop the maximum horse-power possible for their rating, the tax paid per horse-power will be lower the greater the power of the engine. This follows from the fact that for a given rating the horse-power it is possible to obtain is proportionate to the stroke of the engine. The proportion of stroke to diameter, however, is practically limited, but the maximum stroke-bore ratio practicable is the same for any sized engine within the limits ever likely to be used in a car. Hence the larger the engine the longer the stroke and the greater the power obtained for each unit of Treasury rating.

A very little consideration of actual facts will confirm this. Let us, for instance, assume a constant stroke-bore ratio and constant horse-power per cubic inch cylinder capacity. In practice the longest strokes used in cars which have been satisfactory in practice are about twice the bore, while at high revolutions about 1 h.p. per 4 cub. in. cylinder capacity can easily be obtained. On these assumptions the tax per actual horse-power for four-cylinder engines will be for different powers as the curve, in the diagram annexed.

It will be seen that the result is that on the above assumptions the man who has a very little car with a maximum horse-power of 10, pays 11*s.* for each horse-power he can actually get, while the man who can have a 100-h.p. car need only pay a little over 5*s.* Few cars are perhaps built with engines so small that they will only give 10 h.p., but there is a large number with engines which will only give 20, and these will have to pay nearly 9*s.* per horse-power, or in other words 70 per cent. more per horse-power than the 100-h.p. car. If any other stroke-bore ratio and cubic capacity per horse-power be assumed the curve will be exactly the same character.

It may be said that, in practice, cars are not built with such extreme stroke-bore ratios as 2 to 1 as a rule. This is, however, not the issue. Given a rating rule of any kind makers will soon build machines, to suit the rule, as has been proved over and over again as regards motor cars and other machines, and schemes of rating and taxation are usually arranged with full knowledge of this fact.

There appears absolutely no justice or expediency in the new proposals. There may be advantages in graduated payments arranged with an increasing rate of taxation for the wealthier man, but there can be none in a graduated rate in favour of the rich against the poor. Nor can it be said that it is expedient to rate the poor man's car at the higher on the grounds that he uses it more and therefore damages the road more by a higher mileage. As a rule it is the man with a high-powered car who has leisure to run it a large mileage and the poor man who can only take it out for occasional week ends.

So far we have only considered the question of the rating of engines all constructed to get the best out of a given rating, by running at a high speed and employing a long stroke. If we consider the question of such types of engine as give the best result in regards low cost both of construction and upkeep, the case is, however, very much worse. There can be no doubt whatever, both from theoretical considerations and practical experience that a moderate speed engine with moderate stroke is better in every way than the extreme high-speed type and is lighter per horse power. This is sufficiently proved by the following facts: (1) As long as cars were raced under a rule limiting weight but leaving other dimensions free, the moderate speed engine won. (2) In spite of improved materials and much experience, modern chassis with high-speed engines are heavier per horse-power than some of these old cars of fifteen years ago, *e.g.*, the 60-h.p. Mercedes had a chassis weighing under a ton, though its engine would maintain over 60 h.p. (3) Aeroplane engines are never of the extreme high-speed long stroke type, though weight per horse-power is here of the utmost importance, nor are racing motor boat engines. (4) The lightest cars actually in the market having enough power for practical work have moderate speed engines.

Besides being heavy per horse-power the extreme high-speed engine is undoubtedly expensive to build, as the quality of both workmanship and material has to be high, and this fact is not compensated for by the reduced size of the cylinders. We may consider a specific instance of this. The Ford engine has cylinders 3¾ in. by 4 in., and is rated at 20 h.p., which is the power it should give assuming 1,250 revolutions and about 80 lb. mean pressure, both probably fair assumptions. It is quite possible to get the same power out of an engine of the long-stroke high-speed high-compression type with cylinders 2·325 in. by 4·65 in., and these are the sizes assumed in the diagram above. The revolutions would be about 2,500 and the mean pressure 90 lb. to 95 lb. Such an engine would require a bigger crankshaft and main bearings

than the Ford, as well as larger valves. It would, therefore, be heavier. The cost would be a good deal greater, as every part would be larger except the actual cylinder bores and the work would have to be better to stand the high revolutions. There are plenty of cars with such high speed engines on the market, and they weigh as a rule several hundredweight more than the Ford, and cost about twice as much. They are used by a wealthier class of people, and wear the roads more, yet such a car need only pay a tax of 8*l.* 16*s.*, in place of 22*l.* 10*s.*, which a Ford has to pay. In fact, the Ford owner pays over four times as much per actual horse-power as the owner of a special "high efficiency" 100-h.p. car.

It might be said that this argument only applies to one make of car, and that legislation cannot take notice of one particular make. This argument is quite unsound. In the first place when one make of machine has come into almost universal use it is absurd to ignore it. Now it appears that about half the pleasure cars in the world are Fords, and certainly more than half the cars of the really light and cheap class are Fords. In fact, the Ford is pre-eminently the poor man's car, and therefore taxing it is taxing the poor man just as much as if the numbers of Ford cars there are in the country were made by a dozen different makers. In the second place there are other makes besides the Ford, such as the Dodge and Maxwell, which are far more suitable to the poor man than the long-stroke high-speed type, and which are quite as unjustly taxed. In the third, the tax will prevent the English makers developing other cars which could be made in this country to meet an acknowledged demand.

There are other points in which the tax bears very severely on the man of moderate means, while it favours the rich man. For instance, it will come very hard on another useful class of car, namely, the small six-cylinder. In 1916 a car of this type was sold in America, all complete with electric light, self-starter, five-seater body, hood, screen, &c., for under 170*l.* This is essentially a poor man's car, and in these days might be within the reach of a pitman, yet it would have to pay a heavier tax than many four-cylinder cars weighing half as much again, developing a good deal more power and costing a thousand pounds.

All these facts are so obvious it appears hardly credible that they have not been considered, and it almost seems as if it were the deliberate intention either of the Government or those who advised it, to favour the wealthy motorist at the expense of the poorer. What justification there can be for this it is difficult to see. It has been said that the makers in this country have made their engines to suit the rule, and if any other were adopted would have to change their patterns. This is a poor argument, as very few of the makers had designed their engines of anything like extreme dimensions when the tax was relatively low, and a very great many will probably have to do so now if the present rating remains in force. Further, the Ford is now a British make and is entitled to as much consideration as any other.

We have ourselves always advocated a weight basis for taxation, and believe that this is the only fair one, and that its adoption would very much benefit the industry. Makers would then be free to do the best they could on the weight allowable, and could develop much better cars. This would help in the export trade, for it is quite certain that if the makers are forced by the present rating to develop a "rule cheater" for the English market they will be quite unable to compete abroad with the American who has a free hand to do his best. Even if the present rule acts as a measure of protection for the moment, the loss of export trade will certainly be a very much more serious thing to our car builders than the gain in the home market.

THE PROGRESS OF CIVIL AVIATION.

Although the progress of British civil aviation during the half-year ended on September 30 last cannot be said to be strikingly great, it is satisfactory to note from the report recently issued by the Air Ministry that air traffic shows a tendency to increase in volume. The period has, however, to paraphrase the wording of the report, been one of consolidation rather than of radical change, and has been utilised to improve the existing organisation and to provide, as far as is practicable, for the expansion of traffic in the future. During the period 20,658 flights have been made with an average duration of 24 minutes, the number of passengers carried amounting to 32,345, and the distance flown being 689,600 miles. Most of these figures show a distinct increase over the averages for the three half-yearly periods from May, 1919, when civil aviation was inaugurated. The only exception is the number of passengers carried, which shows a slight diminution, the average figure for the three periods being 33,428. The weight of goods carried, however, has steadily increased from 6 tons in the month of April to 23½ tons in September, the total tonnage for the half-year amounting to 86½.

The latter figure is nearly twice as great as that for the two previous half-years together, for which the total was 46 tons, but it must not be overlooked that one of the previous half years covered a winter period. A similar development has taken place in the aerial mail service, the letters transmitted from this country to Paris amounting to 971 in April last and to 7,700 in September, while the total for the half-year was 21,851; during the same period 8,863 letters were forwarded by air mail to this country from Paris. In July last, mail services were established between London and Brussels and London and Amsterdam, and from that time to the end of September, 8,758 letters were despatched to Brussels and 15,566 to Amsterdam. From those cities 4,210 letters and 27,465 letters, respectively, reached this country through the air, and it thus appears that a total of 86,513 letters have been handled by the aerial mail services during the period under consideration.

An idea of the reliability of these services, may be gained from the fact that the total number of outward flights made during the half-year was 409, and of this number 351, or 85·8 per cent., were what are known as Class A. flights, *i.e.*, were completed without a delay of more than 3 hours in any particular case. Of the remainder, 18 (4·4 per cent.) were completed in the same day as the start, but with delays exceeding 3 hours in duration, and 40 (9·8 per cent.) were either completed on the day after the start or abandoned. Accidents, unfortunately, were rather more frequent during the period referred to in the report than in the two previous half years, though the occurrence of one accident in about a thousand flights cannot be regarded as alarming. It is the distressing nature of some of the accidents, such as that which happened on Tuesday last at Golder's Green, rather than their frequency which tends to prevent the public from taking full advantage of the new method of locomotion, so that all concerned with civil aviation should spare no effort, firstly, to reduce the number of accidents to the absolute minimum, and secondly, to lessen the effects of such accidents as cannot be avoided. This year, from April to September inclusive, 21 accidents occurred, 3 of which resulted in the death of 10 persons, including 3 pilots. Seven accidents caused injuries to 4 pilots, 3 passengers and 1 third party, while the other 11 accidents did not involve injury to *personnel*.

There has actually been an average of one accident in every 983 machine flights in the last half-year, as compared with 1 in 1,300 flights for the whole period from the commencement of civil aviation. Similarly we may compare the number of passengers killed and injured per 1,000 carried in these two periods, the figures being 0·22,and 0·10, respectively, for the last six months, and 0·08 and 0·15 for the whole period. The number of machine miles flown per accident, however, shows an improvement, the figures for the last six months and for the whole period being 34,400 and 31,400, respectively. The report, of course, contains no information as to the financial results of civil aviation, and these are certainly less satisfactory than the technical achievements. Doubtless there will be an improvement in this respect when machines designed during the war are entirely replaced by commercial designs, but the need of the industry for direct, or indirect, aid from the State has not yet passed.

THE FORCE-FIELD THEORY AND ELECTRIC RESISTIVITY OF STEEL.

When Mr. Edward DeMille Campbell, the blind professor of Ann Arbor University, Michigan, presented a communication on the influence of heat treatment on the electrical and thermal resistivity and the thermoelectric potential of some steels to the Iron and Steel Institute in 1917,* he was still of the opinion that the peculiarities of steel and similar alloys could in the main be explained by regarding such alloys as solid solutions more or less analogous to the aqueous solutions of electrolytes, in which chemical reaction takes place only between the ions carrying electric charges. In his paper on the "Force-Field Dissociation Theory of Solution applied to Some Properties of Steel," which the Faraday Society discussed last Monday, Professor Campbell no longer accepted the electrolytic dissociation theory. In fact, he characterised that theory as entirely untenable for metallic solutions in which the solvent is not a dielectric like water, but a metallic conductor of electricity. The theory which he would substitute is the force-field theory of solution which Professor E. C. C. Baly, of Liverpool, has developed in the hope of explaining the behaviour of liquid solutions when subjected to the action of radiant energy. One may broadly say, perhaps, that we do not possess any theory yet which satisfactorily accounts for the complexity of the spectrum. Very few of the model atoms suggested deal with any but the simplest elements, though the study of special problems, crystal structure for instance, has borne wonderful fruit. Whether the ideas of Baly and Campbell really bring us nearer to the foundations of the alloy problems, remains to be seen. But in any case they are interesting.

In the first place Professor Campbell referred to the apparent contradiction involved in the term "solid solution" which has been so freely used. Both Dr. A. E. Oxley, who gave an abstract of Professor Campbell's paper [the author was not present], and Sir Robert Hadfield, who presided, objected to the term as misleading. It certainly has been, and may be still; but it is convenient, and Mr. Norbury—to whose paper we shall presently pass—rightly pointed out that the metallurgist has to deal with his "solid solutions" both in the fused and the solid states, and that the simple term "solution" would not suffice. Professor Campbell dwelt upon a second reason why chemists and metallurgists do not regard metallic and aqueous solutions in the same way. The physical chemist expresses the composition of his substances in molecular concentration per unit volume, the metallurgist speaks simply of composition by weight per cent. But the electric and magnetic properties are expressed in units per centimetre cubed. It is therefore preferable to convert composition by weight per cent. into molar quantities, i.e., milligramme-atoms per cubic centimetre, and this is done by multiplying the per cent. of the respective element, *e.g.*, 0·945 per cent. of carbon in a steel, by 10 and the density of the alloy 7·85, and dividing the product by the atomic weight of the element, carbon = 12; thus: $10 \times 7{\cdot}85 \times 0{\cdot}945/12 = 6{\cdot}28$ mil-atoms per cubic centimetre, marks the molar composition of a steel containing 0·945 per cent. of carbon.

According to the force-field theory, to which we now revert, each atom of an element possesses an electromagnetic force field, which is closed when the atoms combine, but opened more or less in steps by the action of solvents, light, &c. Molecules which are inactive are assumed to remain closed. Reactivity is not due to the presence of electric charges or ions, but to force fields, and that applies to all solutions, to gases, liquids and solids. But molecules or crystals not in solution, whose force fields would be assumed to be closed, may, according to Professor Campbell, also possess the property of reacting with certain forms of energy. Further, strictly pure metals would also react with electrical energy—Professor Campbell kept to very general terms—and would possess electric resistivity, which however, did not obey the same law as to temperature influence as did the resistivity due to the

* See Engineering, October 19, 1917, page 422.

reaction of the open force-fields of solutes in solution in the metal. Professor Campbell's resultant of reactivity in metallic solutions is electric resistance, whilst that in aqueous solutions is electric conductance. The reversal of the phenomena he considers due, not to any difference in the atomic relations between the dissolved solute and the solvent, but to the reversal in the electric properties of the solvent—the solvent being in aqueous solutions a dielectric and insulator, in metallic solutions a conductor. Professor Campbell also referred to the law of Wiedemann-Franz [as in his paper above-quoted, the experimental part of which in its practical bearing upon the manufacture of telegraph wires and steel rails was supported by Mr. C. H. Ridsdale], and proposed the term "calohm" as the thermal unit corresponding to the microhm.

Commenting upon this communication Dr. Oxley, of Manchester, remarked that he agreed on the whole with Campbell, but he would not exclude, as Campbell did, the influence of electrolytic dissociation. If we accepted the atom model of a positive nucleus, surrounded and electrically neutralised by electrons, any electron coming very close to the structure or penetrating into it would be in an electric field, though the field as a whole was neutral. If we further assumed the electrons to occupy the corners or other definite positions of a space lattice, those electrons might describe small orbits or represent small vortices, right or left-handed, and would thus create, not only electrostatic, but also electromagnetic fields. The interactions between neighbouring electrons would give rise to the ordinary magnetic phenomena of paramagnetism or diamagnetism, according as neighbouring electrons were rotating in opposite directions or in the same sense. Most organic compounds were diamagnetic; both oxygen and carbon were diamagnetic, and so were the iron and nickel carbonyls; ferricyanide was paramagnetic, ferrocyanide diamagnetic; and it seemed possible to bring these perplexing phenomena and the peculiar temperature ranges of magnetic phenomena into harmony. We should add that the diamagnetism mentioned is exceedingly feeble; in the ordinary sense most of these substances would be called non-magnetic.

With respect to these properties Sir Robert Hadfield pointed out that the alloy consisting of iron-manganese-carbon in the proportions 87 : 12 : 1 was absolutely non-magnetic, but became strongly magnetic by being heated many times to 500 deg. C.; if heated to 800 deg. it completely lost the magnetism. The alloy of iron-nickel-manganese-carbon 80 : 14 : 5 : 1 was also non-magnetic and not reversible as the other. Steel containing about 0·6 per cent. of carbon might be heated thousands of times to 729 deg. C., and would remain soft; but if heated to 731 deg., it would turn hard. That is, as Dr. Oxley pointed out, perhaps not a greater puzzle than the fact that we may heat crystals many times to very near their melting-points without effecting the striking change in the state of aggregation; but it is strange all the same, as Sir Robert had said.

The very instructive paper by Mr. A. L. Norbury, M.Sc., of University College, Swansea, on the "Electric Resistivity of Dilute Metallic Solid Solutions," deserved far fuller consideration than the meeting could accord to it. Mr. Norbury has analysed and tabulated a large number of the experimental data of many observers and has summarised them in diagrams in order to help us to arrive at a quantitive interpretation of phenomena which appear so far little correlated. In his general interpretation of electric resistivity data he distinguishes between (*a*) mutually insoluble compounds and (*b*) mutually soluble compounds. Of class (*a*) his best example was copper and mercury. Copper is a very good conductor, and mercury a poor one, but they amalgamate and are not mutually insoluble, and the only experimental study extant, that of Schleicher, is incomplete. Schleicher arranged pieces of copper wire in glass tubes, partly filled with mercury, so as to represent either a wire of different conductors joined in series, or a conglomerate of crystals in parallel, and he found that in the first case the resistivity (the reciprocal of conductivity) tended to be a linear function of the concentration, while in the latter case it was rather the conductivity which followed a straight line law. Resistivity curves are in general more characteristic than conductivity curves. In the case of the magnesium-tin alloys, the conductivity curve is a broken line, the break corresponding to the compound Mg_2Sn (Stepanow). In the case of copper-bismuth, small additions of Bi rapidly lower the conductivity of the alloy to that of bismuth, the copper crystals becoming surrounded by bismuth (Edwards). When we examine class (*b*), (alloys of components which form a continuous series of solid solutions), palladium-platinum alloys give a symmetrical, slowly ascending and descending curve when we plot resistivity against atomic composition, whilst the curve of palladium-gold alloys is not quite symmetrical, indicating a particular change at a particular concentration. For alloys of class (*b*) Guertler proposed the formula $R = R_1 + R_2$, *i.e.*, the resistivity R of the alloy is the sum of the original resistivities of the constituents and of the "solution resistance" R_2 due to the solid miscibility, R_2 being itself $k \cdot c \cdot (1 - c)$, where k is a constant and c the concentration of one component. Each component has its own k, of course. R_1 seems to be strongly influenced by temperature, R_2 very little; thus the "solid solution resistance" does not vary with temperature, which means that the slope of the resistivity-concentration curves (or straight lines) is the same when the resistances are measured at different temperatures. Clay confirmed this indeed for the resistance of silver-gold alloys; as the silver percentage rises to 30, the resistance curves taken at 0 deg. C., — 104 deg., — 183 deg. and — 253 deg. are all parallel lines, the resistance decreasing, of course, as the temperature is lowered. The solution resistance R_2 is not always constant, however, though for the ordinary temperature range, 0 deg. to 30 deg. C., it may be taken as constant.

As regards the effect of cold work and grain size, Mr. Norbury pointed out that the resistivity of pure silver, gold and copper is little altered by annealing or drawing. In pure iron (0·04 per cent. carbon) Campbell raised the Brinell hardness from 76 to 240 by cold-hammering, whilst the resistivity changed only from 10·50 to 10·63 microhms per cubic centimetre. The effect of cold work and grain size on alloys is much greater, and increases especially as the degree of dispersion increases (Münker). If the constituent of lower conductivity coats the grains of the other constituent, each grain will to a certain extent be insulated, but the grain size will have to become very small before the number of atoms comprising these crystal boundaries become comparable with the total number of atoms present; then, however, the resistance will increase very rapidly.

Coming to the atomic effects of various elements on the resistivity of metals Mr. Norbury pointed out that metals of the same natural group (*e.g.*, platinum metals), have little effect upon one another, at any rate, in diluted solutions. Nickel and cobalt affect the resistance of iron relatively little—apart from special alloys—and cobalt less than nickel and both less than aluminium and copper, which stand further apart from iron; nitrogen and vanadium are somewhat doubtful in their effects. The influence of oxygen in copper alloys is also variable and doubtful whilst hydrogen raises the resistance of palladium considerably. Whether the resistances of alloys show a sudden jump on melting as the pure metals do is still uncertain. The effects of silver and gold on the resistance of magnesium and cadmium are much greater than the converse effects of small quantities of Mg. and Cd on Au and Ag.

Summing up his analysis, Mr. Norbury concluded that the mutual atomic effects are in general greater when the respective elements are far removed from one another than when they belong to the same or related families. The relative atomic effects seemed small when there was little electric attraction between the atoms of solvent and solute. It would not appear to be a question of atomic volumes, but rather of dispersion. That idea would fit into the general conception of space-lattice structure and of electronic conductivity. Foreign solute atoms introduced into a metal, Mr. Norbury suggests, would exert restraining forces on the electrons of the neighbouring atoms of the solvent (and *vice versa*). Since 1 atomic per cent. of arsenic sends the specific resistivity of copper up by about 5 microhms (at very low temperatures as well as at ordinary temperatures), the arsenic atom must be able to influence the resistivity of a large number of surrounding copper atoms. We hope that Mr. Norbury will be able to continue this promising line of research which he is conducting under Professor C. A. Edwards.

We should not omit to state in conclusion that Sir Robert Hadfield, F.R.S., vacated the chair at this annual meeting of the Faraday Society last Monday after seven years of strenuous and fruitful activity, upon which his successor, Professor Alfred W. Porter, F.R.S., of University College, London, dwelt in warm terms. Sir Robert's presidency covers the whole war period, during which, very largely owing to his manifold services as president, the Faraday Society has far more than held its own and has acquired a position of great importance in the world of science.

THE BRITISH MARINE ENGINEERING DESIGN AND CONSTRUCTION COMMITTEE.

THE practical effect now given to the labours of the British Marine Engineering Design and Construction Committee, is sufficient excuse for a short account of the work of this body. Faced with a multitude of rules and conditions, so lacking in uniformity that work designed under one set of conditions failed to obtain classification under another, marine engineers some time ago took up the question of reducing this state of affairs to something like order. As noticed in our issue of last week the outcome of the movement was the British Marine Engineering Design and Construction Committee, which was appointed and supported by the leading institutions and bodies in the country, interested. The movement was actively encouraged by the Institution of Naval Architects, Mr. A. Dansie acting as secretary. On the body there were four representatives of that Institution, and four from each of the following, viz.: The Institution of Engineers and Shipbuilders in Scotland, the North-East Coast Institution of Engineers and Shipbuilders, the Institute of Marine Engineers, and the Liverpool Engineering Society. The three registration societies, Lloyd's Register of Shipping, the British Corporation for the Survey and Registry of Shipping, and the Bureau Veritas International Register of Shipping, were represented on the body by one each. In addition there were four co-opted members of special qualifications. Mr. A. E. Seaton acted as chairman, and did a great deal of valuable work which was of much assistance in bringing about a reduction of the many rules to a uniform basis.

The first definite results were concluded in 1918, when the Committee adopted standard conditions to be observed in the design and construction of marine cylindrical boilers. This work was followed up by treating in the same way the conditions for vertical boilers, for copper and steel pipes, and for shafting for marine engines.

It will be remembered that in his paper on the work of this committee, read before the Institution of Naval Architects in the spring of 1919, Mr. A. E. Seaton expressed the hope that this would be recognised by the Board of Trade. Eventually this was done, and the Board, as mentioned in our pages last week, has recently issued revised standard conditions for marine boilers which are in practical agreement with the unified rules evolved by the Committee. This part of the Committee's labour has therefore been brought to a very satisfactory conclusion.

In their deliberations the Committee worked on as broad lines as possible. The body included members representing practically all sides, including designers and builders, steel makers, classification societies and users responsible for maintenance under ordinary conditions of service. It also collected data relating to Admiralty practice, and, in fact, left no stone unturned to get down to a thoroughly sound basis for future work. A number of researches and tests were conducted, which

were of considerable assistance in the final solutions.

The Committee's report on this part of its work has just been published by the Institution of Naval Architects, from whom it may be obtained at the cost of 5s., in the form of a 70-page interleaved brochure. This volume should prove particularly useful as it gives in parallel the Committee's conditions for design, and the modifications, if any, which have been thought necessary in drawing up the new Board of Trade rules. It will be understood that the Committee has secured agreement to the voluntary adoption of uniform conditions for matters in some cases outside the ordinary sphere of the Board of Trade and the registration societies, as not essential for the safety of life and property at sea. The Committee's report may thus be considered the more far-reaching of the two, and is thus likely to be of inestimable service in marine engineering circles. The manner in which the two sets of conditions are set out side by side is admirable, and will at once show those whose duties call upon them to meet them what degree of variation exists between them, and therefore can be relied upon as a sure guide to sound practice.

The volume in question is concluded by a section on shafts and fittings such as liners, coupling flanges and bolts, crank webs, and keys of propellers. This section is not interleaved with corresponding Board of Trade conditions, but it is interesting to note that the conclusions have been placed before the Board of Trade and the registration societies.

The Committee is now proceeding to consider the subject of water tube boilers, and proposes to deal with it in a similar manner, while it is understood that the body will also be continued for some time, as it is expected that it will be able to render assistance on other matters of general interest in marine engineering, and in elucidating matters which may arise out of the new conditions. That the various bodies have been able voluntarily to come together to thrash such matters out to forms which have proved so completely acceptable to all parties, is high testimony to the thoroughness of the work and the spirit in which it was carried out. It is also eloquent of the progressive attitude of the profession and of the institutions connected therewith, and they are to be complimented upon the results attained, particularly the Institution of Naval Architects, which we believe acted the part of chief promoter of the undertaking.

NOTES.

The New Electricity Bill.

It will be remembered that the Electricity Bill which passed both Houses of Parliament last year, and under the provisions of which various Joint Electricity Authorities are now being formed, originally contained various compulsory clauses which had to be dropped by the Government in order to get the Bill through. It was originally announced that a further Bill would be introduced embodying the compulsory clauses, but in view of the satisfactory progress which is being made with the formation of Joint Authorities under the voluntary scheme it has been decided to proceed with a modified Bill only, and the clauses which were originally objected to have again been dropped. It is characteristic of the Ministry of Transport, however, that we have a kind of half-threat that they may have to bring their rejected clauses forward again some day—if we don't behave ourselves, presumably. An important feature of the new modified Bill is that the originally proposed issue of 25,000,000*l.* electricity stock under Treasury guarantee has again been dropped. This is no doubt to be attributed to a growing appreciation of the national financial position. As, however, the Electricity Commissioners have at present no power over finance, and the existing Bill contains no financial clauses, some method of raising money by the Joint Authorities had to be introduced, and the new Bill authorises Joint Authorities to borrow money, or local authorities and electricity undertakers to lend it to them. This method has the merit of leaving the national credit alone, but the reception which some recent local issues have met does not suggest that money will easily be obtained. Further provisions of the new Bill include power for the revision of maximum charges at intervals of three years instead of the present five, and for enabling railway and tramway generating stations to dispose of surplus power for general public purposes.

Oil Fuel and Shipping.

The opinions recently expressed by Lord Pirrie to the effect that shipowners should not push the conversion of coal-using ships to oil-using ships too rapidly in view of the position of the oil supplies of the world, has attracted much attention. It was referred to by Mr. F. E. Powell, chairman of the Anglo-American Oil Company, at the launching of the oil-engine driven ship Seminole from Messrs. Vickers' Barrow yard last Saturday. It is satisfactory to note, however, that Mr. Powell stated that as far as Diesel fuel was concerned the oil companies of the United States "are prepared to do all that is necessary to guarantee that the supply will be forthcoming." It will be remembered that Lord Pirrie's remarks were directed rather at the steamer converted for oil-burning than at the oil-engine driven ship, and in view of the fact that a Diesel ship requires only about one-third of the oil used by an oil-fired steamship, a possible oil shortage becomes an important argument in favour of the oil-engine ship as compared with the oil-burning steamer. The Seminole is a sister ship to the Narragansett which we described in our issue of May 28 last. She is a ship 425 ft. long, and with a displacement of 14,000 tons, and is fitted with two sets of Vickers' solid-injection type marine oil engines of a total brake horse-power of 2,500. Speaking at the launch of the Seminole, Sir James McKechnie gave some interesting figures in reference to the sea performance of the Narragansett. She had a guaranteed speed of 10½ knots, and it was estimated that she would consume 11 tons of fuel oil per day at that speed. Actually she ran from New Orleans to Liverpool, a distance of 4,500 miles, at 11·1 knots, and used only 9·6 tons of oil a day. This was an excellent performance for a 17-day trip with 10,000 tons of cargo. The boat has since made several voyages to New York and has at times encountered very boisterous weather, but has behaved very satisfactorily throughout.

Well-Boring in Palestine.

If the development of Palestine were to keep pace with the present growth of the literature on the country, Palestine might soon outstrip Wales in population, and also in size, though it scarcely exceeded that country in pre-war time. But the exact frontier and population, a little over half-million probably, of Palestine were always uncertain. A good deal of the war work, for instance, as the well-boring, ought to be of lasting benefit to the country. On this subject Captain Paul H. Mangin communicated a paper to the Institution of Petroleum Technologists last Tuesday. The paper, which in the author's absence was read by Mr. Davson, one of his fellow officers, is instructive as an exemplification of the ways in which competent leaders can overcome great difficulties, even with inadequate equipment and untrained crews. In the maritime plains of Palestine, to which these operations were confined, extending north up to Mount Carmel, water can always be found at depths not exceeding a few hundred feet. But the geology of the country is unknown, treacherous sands predominate, water for drilling had sometimes to be brought up by camels, and the equipments available were, with the exception of one type, unsuitable for the country. The portable plants available, two star rigs, a Columbia driller, and several German power-driven free-fall machines—with which Mr. Davson was in some ways greatly impressed—proved unsatisfactory. The hydraulic percussion rig of the Fauck type alone answered. A short rapid stroke (120 per minute) was used, instead of the usual 30-in. stroke, while a continuous stream of mud-laden water was pumped through the hollow rods and tools, the stream issuing close to the cutting edge of the tools keeping them free from the heavy sand which would otherwise "cushion" the blow. By this method small bores (6 in. diameter) were carried to depths of over 200 ft. The large diameters (10 in.) caused difficulties, and the chief trouble was to keep the sand out of the pipes. Perforated sand screens had to be used; the superior wire gauze screens promised did not arrive till months after the armistice. When the sand was very fine, only an air-lift system would have completely solved the problem. In any case, Captain Mangin referred to the point that the rate of flow of water through unit screen area must not exceed a certain maximum. In many sands this rate was found to be 0·05 in. per second. In the dry sands the bore was kept vertical with difficulty and the augers deflected when depths of 60 ft. were reached, unless provided with auger guides. In some grounds the percussion tool could not be worked, and the ground had to be prepared for the use of the drill. The preparation was effected by introducing clay, either in the shape of hard balls or with the aid of the bailer. The clay accumulates in the bore, however, and could not always be removed before inserting the sand screens, which the clay choked; such screens could not be dislodged again afterwards. In the two years of the operations 45 wells were altogether bored, the maximum depth being 304 ft. One point emphasised by Captain Mangin and Mr. Davson was that, though the men were inexperienced, they soon learned to understand the records which would be of permanent value, all the more because contractors were too prone to keep their figures to themselves or to use them merely for their own purposes.

LITERATURE.

American Shipbuilding Cyclopedia. By F. B. Webster, Editor; J. L. Bates and S. M. Phillips, Associate Editors; and A. H. Haag, Consulting Editor. New York, U.S.A.: Simmons-Boardman Publishing Company, Woolworth Buildings. [Price 3*l.* cloth binding, 4*l.* leather binding.]

The war development of the shipbuilding industry in America and the future of that industry are subjects of the very first importance not only to America but also to Britain, for it seems probable that competition between the two countries will be extremely keen, and the recent achievements of American shipbuilders are such as to compel serious consideration by all their competitors, particularly British. To many in this country the recently-published figures showing the American output at 4,000,000 tons for a period of twelve months came as a surprise and a revelation of the enormous growth of American shipbuilding plant within recent years. Whether this gigantic and rapidly-organised plant can be successfully operated under competitive conditions it is as yet too early to judge, but the fact that it could achieve the output quoted above is ample evidence that it possesses at least some of the requsites of a keen and successful competitor.

A good deal has been written regarding the organisation and plant which has been created in America largely to meet the urgent demands of war-time conditions which have now ceased to operate. The most urgent demand during the war period was naturally speed of construction, and to ensure this, plant and organisation were designed on lines approximating to those of the large engineering factories in which machinery is employed to the highest possible extent for all manufacturing processes. The installation and use of machinery wherever possible was further necessitated by the shortage of skilled workers, and as a result the new American yards are, from the point of view of machinery equipment, considerably ahead of most of the shipyards of this country. Whether or not this is altogether an advantage will depend upon several important considerations, of which the ability to keep the plant continuously employed on suitable work is the most important. Under normal pre-war conditions few British shipyards were working up to full capacity, and there seems a strong probability that similar conditions will obtain in America in the near future, in which case the establishment charges due to capital sunk in only partially productive machinery may become prohibitive. Whatever be the future position occupied by the American shipbuilding industry there can be no doubt about the enormous strides made by that industry within recent years, and a

natural result of this has been the publishing of a number of text books dealing with the problems of wood and steel ship construction as met and dealt with in America. Among such publications the "Shipbuilding Cyclopedia" occupies a position of more than usual interest in that it covers a broader field than is usual in technical text books, and publishes for the first time plans of many of the steel vessels designed and built in America.

"A Dictionary of Ship and Shipbuilding Terms" occupies the first 150 pages, and will probably prove extremely useful in American shipbuilding circles where such a large proportion of the operatives are newcomers to the industry and totally ignorant of shipbuilding terms. This section is well arranged, and gives a very comprehensive collection of definitions, but in some cases they are a little different from British interpretations. It is an obvious oversight which describes the flukes of a stockless anchor as the crown and *vice versa* on page 2, but the statement on page 18 in the definition of "Bulldozer" as a machine for bending frames, &c., stating that "this work is done cold," is certainly misleading, as it is impossible to set the frames of a vessel of ordinary construction cold. On the whole, however, the definitions are concise and lucid and will no doubt prove useful.

The section dealing with "Basic Design" presents no striking novelties, but is none the less a most excellent presentation, both in sequence and in treatment, of the solution of the problems of ship design. The author of the section, Mr. J. L. Bates, has carried out a difficult task in a thoroughly satisfactory manner, and his exposition of the methods of assigning tentative values to the often conflicting elements of a design is excellent, while his plea for systematic recording and investigating of all data relative to design and actual performance cannot be too strongly urged upon student and designer alike.

"Planning and Estimating," a chapter by Mr. Stephen M. Phillips, describes in some detail plant management, the work of the drawing office and estimating departments, and contains illustrations of the lay-out of the plant in typical American yards. In general it may be said that the author advocates a system of planning and routing of material and jobs through the shops similar to that in operation in most American engineering factories. The conditions under which the shipbuilding industry of America was developed were undoubtedly entirely favourable to the application of the factory system, and indeed in the prevailing shortage of experienced and skilled shipyard managers and foremen the adoption of some such system was almost a necessity. To what extent planning and routing of work as arranged by a department not responsible for the operation of the machinery involved can be satisfactorily applied in practice is a question not easily answered, but from a British point of view there would certainly seem to be a very strong probability of serious friction between the planning department and the shop foremen. Experience shows that shipyard jobs in British yards do not as a rule pass through the machine shops in the theoretically best manner; plant breakdowns, avoidable or unavoidable absence of workmen on particular jobs, non-delivery of part or all of the material required, &c., render working to any rigid routing or planning system economically impossible, while the state of the labour market frequently makes a departure from the theoretical rotation of jobs passing through the shops a matter of urgent necessity. The orderly sequence of work through the shops as described by the author is theoretically most admirable, and in the present relatively undeveloped state of trades unionism in the States may be quite workable, but it is to be feared that its introduction in this country would not only create friction but would involve the addition to the staff of a considerable number of men whose function is at present carried out by head foremen and departmental managers. The hints given on the compilation and use of data for estimating purposes are sound, and will form a good guide for those who have not already evolved a standard form for the recording of all data relative to their vessels. The chapter concludes with several most excellent plans illustrating the lay-out of plant in various yards, and a study of these shows at once that lavish equipment and skilful lay-out of the plant are characteristics of the modern American shipyard.

A chapter on "Ships' Rigging and Cargo-Handling Gear," by Mr. Alfred H. Haag, in which the author describes and illustrates the construction of masts, derrick posts, derricks and their fittings, provides a fund of reliable information of considerable value. Like all who have had occasion to deal with rigging and cargo-handling gear the author deplores the lack of uniformity in fittings and makes a wholly reasonable plea for standardisation in these items. Although the author has confined himself to the commonest form of cargo-handling gear and has dealt with the subject from the purely practical point of view, the excellence and number of illustrations furnished and the wealth of detail given thereon are bound to prove of great value to many who have not access to such information. A table, compiled by the American Bureau of Standards, of weights per cubic foot, space occupied per ton, and method of packing for all items of cargo usually met with will be found of considerable use by shippers and all those interested in the stowage and carriage of cargo.

Perhaps the most interesting feature of the volume is the collection of ships' plans, illustrating many types of vessel built in American shipyards. As a complete record of modern American shipbuilding practice the collection is of the highest value, for not only does it contain the usual general arrangement and midship section plans for steel vessels and wood sailing and auxiliary vessels, but also detail plans of practically every item in the construction and outfit of modern steel vessels. Among these plans may be mentioned engine and boiler arrangements, piping, ventilating and electrical arrangements, shell expansion, framing plan and framing sections, bulkheads, casings, deckhouses, deck plating, stern posts, bilge and ballast suctions, propellers and shafting, rudders, joiner work details, &c., &c. As the vessels illustrated range from a 13,000-ton deadweight combined passenger and freighter to a harbour tug, and include ordinary cargo vessels, oil-carrying vessels, wood sailing and auxiliary vessels and reinforced concrete vessels, the range includes practically all the more usual types of vessel. In all cases the quality of the reproductions is of the very highest, and every detail of line and letterpress is clear and readily followed. A great deal of information relative to the vessels accompanies many of the illustrations, and the whole section is the finest thing of its kind we have yet seen published. A catalogue section of over 400 pages giving detailed information regarding the various items of equipment for shipyard and ship, and the names of the makers, completes the book, and will be of considerable use to those whose business it is to purchase equipment of any kind.

As a general reference book for all engaged in the American shipping and shipbuilding trades the volume is of undoubted value, while as a record of American thought and achievement in shipbuilding it is worthy of the serious attention of all interested in the future of the shipbuilding industry in this country.

Deeds of a Great Railway; A Record of the Enterprise and Achievements of the London and North-Western Railway Company during the Great War. By G. R. S. DARROCK (Croix de Guerre), with a preface by L. I. MAXSE. London: John Murray. [Price 15*s.* net.]

"THE Railway Executive Committee have been too modest, the public do not know what they achieved." These words, quoted on the title page of Mr. Darrock's book, are taken from an article on "The Railway Problem," which appeared in our columns nearly two years ago, and in these two years, during which many aspects of the war have been discussed and many reputations enhanced or damaged, little has been done to bring home to an indifferent public the extent of their indebtedness to the untiring labours of those who devoted themselves wholeheartedly to the production and transport of those military stores, that in the end turned the tide of victory. The author, who has played his part, both in the stricken field and in the ranks of those who have trained and directed the efforts of industrial enterprise along new and unfamiliar paths, is well qualified to supply correct information and to remove any mistaken impression that may have been entertained of the value of the civilians' share in the struggle, as also to present in a proper light both the self-sacrifice that animated the industrial world and the ingenuity displayed in the combination of the efforts of workers, by which success alone could be achieved. A great engineer organising and disposing of energy, human or mechanical, occupies a post as responsible as that of a general in the field. This truth may not be stated in so many words in Mr. Darrock's book, but it is impossible to miss such a reading between the lines. The consequences of failure or incompetency are liable to be not more disastrous in one case than in the other.

Dazzled by some brilliant strategical movement that wins success in the field, little attention is given to the nice adjustment, to the adequate training required, or the accurately-thought-out preliminary measures, which secured such a success, and applause is awarded only to the spectacular denouement. On the industrial leader who has organised armies of labour, devised machinery, harmonised conflicting interests, and ensured the provision of the necessary war material, very little consideration is bestowed. In this instance, the general in command was Mr. C. J. Bowen Cooke, whose lamented death was announced in these columns a few weeks since. Doubtless if other works and other endeavours had been described other names would have commanded our admiration and our gratitude. The author is writing of the Crewe works and the London and North-Western Railway, but the lesson is the same in other cases. Everywhere most admirable will and determination were exhibited, the results obtained being limited only by the extent of the available means, and it is right that the public should comprehend and acknowledge what our engineering shops effected towards bringing the war to a successful conclusion.

While the author demonstrates the numerous activities in which the industrial staff of the London and North-Western Railway participated and makes evident the value of versatile and well-directed energy, his aim is far wider. He is penetrated and dismayed by the evident unpreparedness that marked the outbreak of hostilities. He insists on the loss of valuable lives and time and treasure that followed from the want of sufficient and appropriate equipment, and comments on the general unreadiness that was manifested. It is urged that the hairbreadth escapes from which the country happily emerged, constitute a very severe condemnation on the policy of those who were responsible for the conduct of military operations, and occupied a prominent place "in the arena of political pantomimics." We doubt, however, if the unreadiness were quite so great as it appeared, or the consequences as disastrous as represented.

In considering this point it must be remembered that the moment selected for the declaration of war, with all the advantages this choice entailed, was at the command of the enemy. And further, an autocratic Government, responsible only to itself, has a great superiority over a democratic, whose leaders have to justify their conduct to their supporters and whose arguments must convince their opponents. Mr. Darrock gives us some quotations from the *Daily News* and *Daily Chronicle* in the early days of August, 1914, which show that there was a strong party in the country who put trade before honour and sought profit rather than duty. Yet on August 18, but one short fortnight after our declaration of war, "an expeditionary force as detailed for foreign service landed on French soil." The machinery that collected the troops from all parts of our islands, conveyed them to their several ports of embarkation, and without a single casualty despatched them across the narrow strip of water that might have proved the grave of thousands, was not inefficient. The British railway companies worked silently and worked well, and from this initial feat of achievement throughout the long and anxious years that followed, they proved themselves equal to all emergencies imposed on them. And Mr. Darrock explains why the stupendous programme assigned to the railway companies was satisfactorily fulfilled. Fortunately, he says, the staff of each railway remained during

the war under the control and received their orders from their own officers. The result was that undisturbed by the interference of a crowd of inefficient experts, and unmolested by any kind of official bureaucracy, knowledge and experience were allowed their full effect. The author is no friend to that elaborate system of control and inspection, so dear to the heart of officialdom, and especially to the Ministry of Munitions. The improvised arsenal at Crewe did not suffer greatly from that army of "inspectors, and inspectors of inspectors, super-inspectors, and inspectors-general," and the whole family of Tite Barnacle that battened, and it is to be feared, are still bleeding a long-suffering nation, for Mr. Cooke was a strong man and would have none of these "inexpert experts." In fact he threatened to withdraw his offer of steel manufacture if the confidence which he reposed in his small entourage of professional experts was not shared by, and admitted as sufficient, by the military authorities. An amusing story is told in connection with the process of drop-stamping, an art carried to perfection at Crewe, of one of these experts, clad in gorgeous khaki, claiming admission to the Crewe works "for the purpose of satisfying himself that the engineers in the London and North-Western Locomotive Department were making the best of the drop-hammer plant!"

Another object which the author has at heart and with which we cordially sympathise, is to remind us that it is not sufficient to beat the enemy in the field but we have also to measure ourselves against his subtlety at the Council Table, lest "having won half the world by bloody murder, they win the other half with tears in their eyes crying for mercy." Just as we have little genius for everything appertaining to war, so we fail in the capacity of making a durable and judicious peace. Mr. Darrock detects, or we greatly misunderstand him, a tendency to view the German not as he is, but as we would like to think him. His rapacity is exhibited in the treaty enacted from Roumania in the day of his might; his capacity for extortion in the ransoms demanded from the French and Belgian towns that fell into his plundering hand. The injunction of Bismarck to leave to the populations through which the German hosts passed "only eyes to weep with" has been strictly followed by those who had both the power and the will to practice the precept. Mr. Darrock's picture of the Hun is as faithful as it should prove salutary.

In conclusion it ought to be said that this exhilarating tale showing how a modern works devoted to the arts of peace was tranformed by deliberate and concentrated effort in an incredibly short time into a modern arsenal, is not dwarfed by the inclusion of any unnecessary detail. The earnestness and the devotion exhibited in every department are the features on which attention is centred. The magnificence of the outcome can be concluded without any meretricious ornament. Too much detail and too many statistics would rob the main story of its significance. We have, as Mr. Maxse declares, "a wonderful and stimulating story—made all the more interesting because the author continually bears in mind that it is part of a still larger whole and breaks what is entirely new ground to the vast majority of the reading public."

BOOKS RECEIVED.

How to Drive a Motor Car. Seventh edition. London: Temple Press, Limited. [Price 3s. 6d. net.]

The Motor Cycling Manual. Fifth edition. London: Temple Press, Limited. [Price 2s. 6d. net.]

Transactions of the Liverpool Engineering Society. Vol. XL. Forty-fifth session. Edited by T. R. Wilton, M.A., Assoc.M.Inst.C.E. Liverpool: Published by the Society, Royal Institution, Colquitt-street.

Die Maschinen-Elemente ihre Berechnung und Konstruktion. Vol. I. Von C. Bach. Twelfth edition. Stuttgart: Alfred Kroner. [Price 66 marks.]

Coal Saving in the Chemical Industry. The Scientific Control of Boiler Plant. By David Brownlie, B.Sc., F.C.S., A.I.Mech.E. Manchester: Brownlie and Green Limited. [Price 2s. 6d.]

Science German Course. By G. W. Paget Moffatt, M.A., M.B., B.C. With a glossary by J. Bithell, M.A. Third edition. London: University Tutorial Press, Limited. [Price 5s.]

Steam Shovel Mining: Including a consideration of Electric Shovels and other Power Excavators in Open Pit Mining. By Robert Marsh, Junior. New York and London: McGraw-Hill Book Company, Inc. [Price 21s. net.]

United States Geological Survey. No. 1: 5. *Cadmium in 1917.* By C. E. Siebenthal. No. 1: 9. *Gold, Silver, Copper and Lead in South Dakota and Wyoming in 1916. Mines Report.* By Charles W. Henderson. No. 1: 10. *Gold, Silver, Copper, Lead and Zinc in California and Oregon in 1915. Mines Report.* By Charles G. Yale. No. 1: 11. *Gold, Silver, Copper, Lead and Zinc in the Eastern States in 1916. Mines Report.* By James M. Hill. No. 1: 12. *Iron Ore, Pig-Iron and Steel in 1915.* By Ernest F. Burchard. No. 1: 19. *Gold, Silver, Copper, Lead and Zinc in Montana. Mines Report.* By V. C. Heikes. No. 1: 22. *Metals and Ores in 1914 and 1915.* By J. P. Dunlop. No. 1: 23. *Manganese and Manganiferous Ores in 1916.* By D. F. Hewett. No. 1: 24. *Nickel in 1915.* By Frank L. Hess. No. 1: 27. *Antimony, Arsenic, Bismuth, Selenium and Tellurium in 1915.* By Frank L. Hess. No. II: 3. *Lithium Minerals in 1916.* By W. T. Schaller. No. II: 6. *Talc and Soapstone in 1917.* By J. S. Diller. No. II: 7. *Graphite in 1916.* By Henry G. Ferguson. No. II: 8. *Graphite in 1917.* By Henry G. Ferguson. No. II: 11. *Feldspar in 1916.* By Frank J. Katz. No. II: 19. *Silica in 1916.* By Frank J. Katz. No. II: 22. *Flourspar and Cryolite in 1916.* By E. F. Burchard. No. II: 24. *Cement in 1916.* By E. F. Burchard. No. II: 25. *Zirconium and Rare Earth Minerals in 1916.* By W. T. Schaller. No. II: 26. *Borax in 1916.* By Charles G. Yale and Hoyt S. Gale. No. II: 29. *Gems and Precious Stones in 1915.* By W. T. Schaller. No. II: 32. *Borax in 1915.* By Charles G. Yale. No. II: 33. *Magnesite in 1915.* By Charles G. Yale. No. II: 34. *Peat in 1915.* By James S. Turp. Washington: Government Printing Office.

United States Geological Survey. Bulletins: No. 624. *Useful Minerals of the United States.* Compiled by Frank C. Schrader, Ralph W. Stone, and Samuel Sanford. No. 640–F. *The Golden Arrow, Clifford, and Ellendale Districts, Nye County, Nevada.* By Henry J. Ferguson. No. 640–G. *Tin Ore in Northern Laudes County, Nevada.* By Adolph Knopf. No. 641–G. *Geology of the Upper Stillwater Basin, Stillwater and Carbon Counties, Montana, with special reference to Coal and Oil.* By W. R. Calvert. No. 642. *Mineral Resources of Alaska. Report on Progress of Investigations in 1915.* By Alfred H. Brooks and others. No. 648. *Notes on Some Mining Districts in Eastern Nevada.* By James M. Hill. [Price 20 cents.] No. 654. *Spirit Levelling in Nevada, 1897 to 1916 inclusive.* R. B. Marshall, Chief Biographer. No. 660–F. *Ore Deposits of the North-Western Part of the Garnet Range, Montana.* By J. T. Pardee. No. 660–G. *The Dunkleberg Mining District Granite County, Montana.* By J. T. Pardee. No. 661–I. *Phosphate Oil Shales near Dell and Dillon, Beverhead County, Montana.* By C. F. Bowen. No. 690–D. *Quicksilver Deposits of the Phœnix Mountains, Arizona.* By Frank C. Schrader. No. 690–F. *Some Manganese Deposits in Madison County, Montana.* By J. T. Pardee. Washington: Government Printing Office.

THE LAW OF NUISANCE.

Lord Blackburn, one of the judges of the Court of Session in Edinburgh, has given judgment in a case of alleged nuisance which forms an interesting contrast to the recent judgment of Mr. Justice Astbury in the Battersea saw case. The Scottish case related to the use of heavy drop-hammers in the works of the defendants, Messrs. Charles McNeil, Limited, hydraulic forgemasters, Kinning Park, Glasgow. In 1916, in order to increase the output of certain steel forgings which were urgently required by the Government, the defendants acquired additional ground in the vicinity of their existing works and erected new buildings in which they installed six heavy drop-hammers—one of 15 cwt., one of 3 tons, two of 35 cwt., one of 4 tons and one of 5 tons. The first four were installed early in 1917, the other two being installed after the armistice. The works are situated in a busy industrial district in which there are many engineering works, but the drop-hammers were the first to be used in the district, although the defendants and other engineering firms had had heavy steam hammers at work for many years.

The use of the hammers led to some complaints by neighbours during the war and ultimately to the commencement of legal proceedings at the instance of the Roman Catholic Archdiocese of Glasgow, who were proprietors of a church, presbytery, school and some houses and business premises, in the neighbourhood, and Messrs. Smith Brothers and Co., who carried on an engineering works immediately adjacent to the defendants' new works. It was alleged that the vibration from the blows of the hammers had caused structural damage to the properties of both complainers, and that it interfered with the work carried on in them; and the Roman Catholic Archdiocese complained that the noise interfered with the conduct of services in their church and with the teaching in their school. The plaintiffs seemed to have tried to establish that although there was a certain amount of noise and vibration in the district the drop-hammers had created effects materially different from those arising from the use of the existing steam hammers, but Lord Blackburn held that this had not been established. The case, therefore, differed from the Battersea and Chelsea case, because there the defendants had introduced a high-speed friction saw which made a peculiarly irritating and distracting noise which was materially different from the other noises in their works. Another striking point of difference was that Chelsea was held to be a residential and not an industrial district.

Lord Blackburn, reviewing the evidence, held that it was not proved that the plaintiffs' premises had sustained any damage which could be attributed to the hammers, or that the work in the premises of Messrs. Smith Brothers and Co. had been interfered with by the vibration. The most difficult part of the case related to the effect of the noise and vibration on persons who attended the church and school and lived in the presbytery. His Lordship was satisfied that the complainers' witnesses honestly regarded the hammers as having introduced a serious interference into the neighbourhood, but he thought that as soon as it was realised that drop-hammers were to be introduced the complainers and the witnesses became prepossessed with the idea that the hammers were a novel introduction calculated to create a much greater disturbance than any machinery previously in use in the neighbourhood; that this impression was fostered by the fact that the hammers were used night and day during the war, that the witnesses' impressions were exaggerated, and that in fact the defendants had not introduced such a serious addition to the existing discomforts of the neighbourhood as amounted to a legal nuisance. He therefore refused to grant an interdict or injunction against the use of the hammers.

It will be observed that the plaintiffs' case failed entirely on the facts. Lord Blackburn was quite in agreement with the view of the law prevailing in the English Courts that whatever the standard of comfort may be in a particular district, the addition of a fresh noise, if substantial, may create a legal nuisance. In other words, "If a substantial addition is found as a fact in any particular case, it is no answer to say that the neighbourhood is noisy." He held, however, that there was no substantial addition to the noise or vibration in the district, whereas in the Chelsea case the plaintiffs succeeded because the noise from the saw was distinct from the other noises of the district and formed a substantial addition to them, and because Mr. Justice Astbury was satisfied that the evidence for the plaintiffs was not exaggerated.

The two cases are interesting examples of the operation of the same principles of law, and the fact that while the one succeeded the other failed was due merely to the difference in the facts established by the evidence.

British Production of Pig-Iron and Steel.—The production of pig-iron which, owing to the coal strike, fell in October to 533,200 tons, further fell in November to 403,800 tons. The production of steel ingots and castings in November amounted to 503,900 tons, as against 544,300 tons last October.

The late Mr. Jacob Higson.—We regret to learn of the death, which occurred on the 18th ult., at his residence in Northwood, Middlesex, of Mr. Jacob Higson, a member of the Institution of Mining Engineers, of the Institution of Mechanical Engineers and of the Institution of Civil Engineers. Mr. Higson was one of the earliest Inspector of Mines under the Act of 1851. He was born in 1837, and was educated at Owen's College, Manchester. After seeing service in the Crimean War, he returned to Manchester and founded the firm of J. and P. Higson, mining engineers. Mr. Higson was prominently connected with the Lancashire and South Wales collieries, and was a director of several mining companies having interests in Spain, Portugal, North and South America, and South Africa. He was keenly interested in the welfare of all who worked under him, and readily came forward many a time for rescue work in mine disasters.

Dust-Recovery Plant Contract.—Judgment was recently delivered by one of the official referees in an action in the King's Bench Division, in which Messrs. Keeling and Walker, Limited, of Stoke-on-Trent, sought 8,525*l.* 19*s.* 4*d.* damages for alleged breach of contract in connection with an installation of a dust-recovery and cooling plant used in the manufacture of zinc oxide. The effect of the evidence was to show that the recovery plant in question was of the suction filter type, claimed to have advantages over the ordinary type of pressure filter used in recovering zinc oxide in the course of manufacture; that, when set to work, certain modifications were found to be necessary; but that before they could be effected, Messrs. Keeling and Walker, Limited, on their own motion, altered the design of the furnace and the arrangement of hoods and connecting pipes. After hearing Messrs. Keeling and Walker's case, and without calling on the contractors, the Official Referee delivered judgment for the contractor (The Sturtevant Engineering Company, Limited) with costs, holding that there had been no breach of contract and that the claim failed. The counsel for the plaintiffs were Mr. Maddocks, K.C., M.P., and Mr. Sturge, and for the defendants, Sir Malcolm MacNaughten, K.C., and Mr. Theo. Mathew.

ELLIPSOGRAPH FOR MANHOLE CUTTING.

CONSTRUCTED BY THE BRITISH OXYGEN COMPANY, LIMITED, ENGINEERS, LONDON.

Fig. 1.

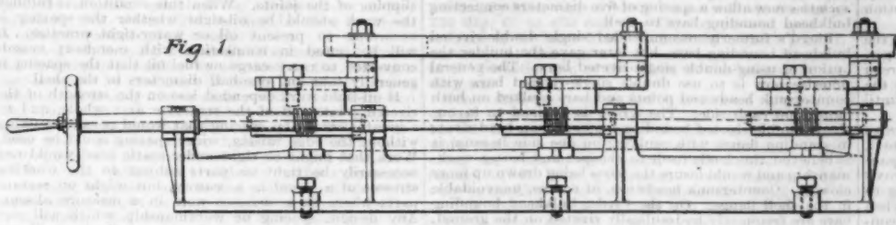


Fig. 3.

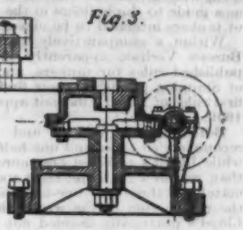
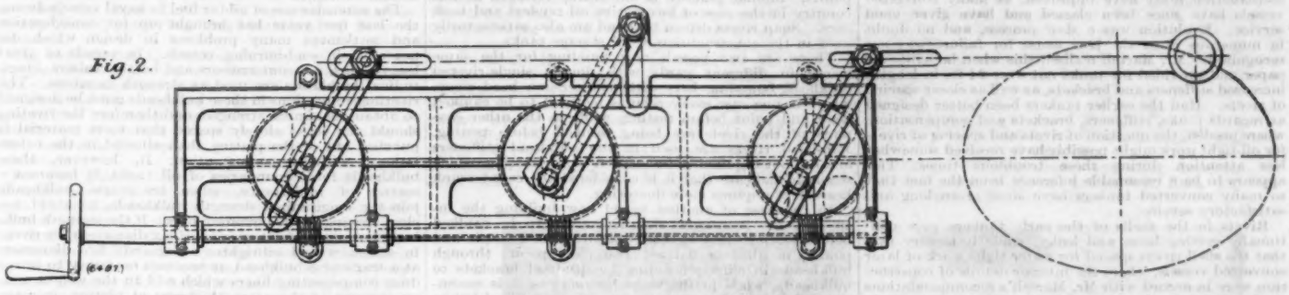


Fig. 2.



THE accompanying illustrations show a simple and convenient form of ellipsograph for cutting manhole openings in steel plates for boilers, tanks, and structural work by means of the oxy-acetylene blowpipe. The appliance, which was patented by Mr. J. McNeil, of Messrs. Charles McNeil, Limited, Glasgow, and is made by the British Oxygen Company, Limited, Elverton Street, Westminster, London, S.W. 1, requires but little explanation, its construction being clearly shown in the elevation, plan and cross-section, Figs. 1, 2 and 3, respectively, and its geometry being practically obvious.

Briefly, it consists of a cast-iron base plate carrying three crank discs, which can be rotated synchronously by means of worm gearing operated by a hand-wheel shown on the left of Figs. 1 and 2. Each crank disc is provided with a slotted crank arm, all three of which are set parallel. These arms can be clamped to give any throw within the limits for which the particular machine is designed. Mounted on the three crank-arms is a bar, the two outer crank-pins working in slots parallel with the length of the bar, while the intermediate crank-pin works in a slot at right angles to the others. This bar carries at one end (that on the right of Figs. 1 and 2), the blow-pipe, which is supplied with gas through flexible tubes and can be adjusted vertically to bring a suitable part of the flame into contact with the plate on which the whole machine rests.

If it is desired to cut a circular hole, all the three crank-arms are set to the required radius, the adjustment being facilitated by graduations indicated in Fig. 2, and, on rotating the hand-wheel, the blow-pipe will describe a circle and cut a circular hole in the plate. To cut an elliptical hole, as shown by the chain-dotted line in Fig. 2, the two outer cranks are set to a radius equal to half the length of the minor axis, while the intermediate crank is set to half the length of the major axis. Since all the crank-pins are free to move longitudinally, but not laterally, in their respective slots, the effect of the intermediate crank is to impart a longitudinal simple-harmonic motion to the bar, in addition to the circular motion due to the other two cranks, the maximum longitudinal displacement of the bar occurring when the latter is parallel with the cranks. The combination of the two motions causes the bar to describe an ellipse, and, by adjusting the effective length of the crank-arms, the ellipse may be made of any desired proportions, even to the limiting case of the straight line. Such an "ellipse" would, of course, not be required in practice, but it is interesting to notice that it would be produced if the throw of the two outer cranks were reduced to zero, while that of the intermediate crank had a finite value.

It is also, perhaps, hardly necessary to point out that, although we have only considered the case in which the length of the intermediate crank is greater than that of the outer cranks, ellipses can also be described when the intermediate crank is shorter than the others, but, in this case, the major axis would be vertical in Fig. 2, instead of horizontal. The appliance illustrated is suitable for cutting ellipses up to 24 in. by 18 in.

NOTES ON RIVETS AND SPACING OF RIVETS FOR OIL-TIGHT WORK.*

By HUGO P. FREAR, Member.

IT is improbable that the writer would have selected the above subject, which was assigned to him, had he volunteered to submit a paper at this session. The secretary usually sends out notices at an early date inviting members to recommend subjects and authors, and "Rivets and Spacing of Rivets for Oil-tight Work" appears to be one of the topics which attracted the attention of the Council. An exhaustive treatment would be largely a matter of compilation and beyond the scope of this paper, and will not be attempted, it being the desire rather to invite discussion if there is a difference of opinion regarding general practice or on the few points raised, without which the paper will be of comparatively little value.

The present high state of efficiency of the modern tanker leaves little to be said on rivets and rivet spacing for oiltight work that would be both new and conservative, and it may be safely said that radial departures from the practice arrived at as the result of years of experience would invite trouble. Riveting is unquestionably one of the greatest, if not the greatest, item of expense entering into the cost of construction, and the unprecedented demand for tankers and oil-burning vessels at this time magnifies its importance. Experience has become much more general in both the building and operating of tankers, and perhaps this was thought to be an opportune time to provoke discussion along other than traditional lines.

Rivets and spacing of rivets for oiltight work, as covered by the Classification Rules, Navy Department, British Admiralty, &c., does not vary radically although, on account of higher stresses used, a greater spacing is adopted in some parts for naval vessels. It must be borne in mind, however, that naval vessels are not subject to the great variations in load encountered in the merchant marine, and therefore the stresses can be anticipated with greater accuracy.

Rules for rivets and rivets pacing are the result of evolution arrived at by rule of thumb, experience, size of rivet found practicable to drive, spacing suitable for caulking, experiments, calculations, survey reports on damage cases, &c., and are in the opinion of the writer generally satisfactory with very few exceptions, which will be referred to later.

Oil-tightness depends, perhaps, more on good workmanship than any other one thing, especially so far as riveting is concerned. If every rivet could be guaranteed 100 per cent. perfect, slightly greater spacing would be practicable and might be allowed by classification societies except where a given efficiency of joint is essential. The same standard of workmanship does not exist throughout the yards of the world, or in some cases even throughout the same vessel. It is obvious that there must be a common rule for all and, therefore, the required rivet spacing is designed to guarantee good results for average standards of workmanship.

It was stated above that the rules for rivets and spacing of rivets for oil-tight work had been arrived at by a process of evolution, and it may not be out of place to refer briefly and in a very general way to some of the early bulk oil carriers and to some precedents in connection with conversion jobs on account of the large number of vessels which have been, and will be, converted to carry fuel oil.

While there were probably some barges in existence prior to 1872, it was in that year that the first bulk oil-carrying steamer was built at Palmer's, Newcastle-on-Tyne, England. Although this vessel was built especially for carrying oil in bulk, she had a double bottom, and the indications are that the rivet spacing was the same as in vogue at that time for watertight work. Following this date, new bulk oil carriers were built from time to time, but perhaps for about three decades converted vessels contributed more or less to increasing the fleet.

During this period the spacing of rivets, even for water-tight work, was in some respects greater than at present, and vessels frequently leaked a little when new, but they were built of iron and the joints soon rusted up tight, thereby increasing the friction of the riveted joints and resulting in stronger and more durable vessels under existing conditions. This rusting-up process, however, would not take place in the case of new vessels built to carry crude or lubricating oils in bulk, and on that account some of the converted vessels were tighter than new tankers. It was during this period that the importance of the friction of the joint referred to above became more generally appreciated.

Oxidation, however, takes place in tanks carrying gasoline, and this rusting-up process, undoubtedly, penetrates into the seams. On this account it might be beneficial to carry a cargo of this character on the first voyage or two as is sometimes done. Tests have demonstrated that, while the friction of the joint has no effect on the ultimate strength, it has a safe factor above working stresses where workmanship is good. If there is the slightest slip, defective rivets will come to light; therefore, in oil-tight work intimate metal-to-metal contact is of the greatest importance for permanent oil-tightness, especially where subject to alternating stresses set up by the working of the ship.

Serious recurring damage, constant necessary repairs and resulting cost to underwriters during much of this part of the history of oil carrying in bulk were attributed to inadequate scantlings, improper distribution of material, insufficient riveting, poor workmanship, long tanks, overloading and limited knowledge of manipulating large quantities of water ballast, especially in the case of exceptionally long tanks. Investigation by Dr. James Montgomerie over a period of thirteen years prior to 1909 conclusively showed that recurring damage was more frequent where the tanks were over 30 ft. long.

The early tankers, both new and converted, had relatively less beam and were consequently easier in a seaway, yet the penetrating character of the oil sought out weak spots and loosened rivets developed under new stresses created by carrying oil in bulk. The first leaks frequently occurred at the ends of stiffeners and in rivets connecting frames to shell which were subject to stresses not common in ordinary vessels. After these started the vessel began to work more, and progressive damage followed, frequently resulting in almost entirely re-riveting the vessel.

There was a fad about this time for plug-headed rivets, but these were abandoned because they would not draw the work up sufficiently close and created greater difficulty in securing high quality of workmanship. The old reliable pan head was found to produce the most intimate contact and to be more permanently oil-tight and was recommended except where some other types were absolutely necessary.

Up to 1894 there were built or building to Lloyd's Class 64 tankers, yet the society did not consider that it had sufficient experience to lay down definite rules for

* Paper read before the Society of Naval Architects and Marine Engineers, at their New York meeting, November 11 and 12, 1920.

their construction. In this year, however, Mr. Benjamin Martell, Chief Surveyor to Lloyd's Register, read a paper before the Institution of Naval Architects wherein he outlined his views on the details of construction and of riveting for bulk oil carriers, recommending three diameters for oiltight work. This paper in pamphlet form was distributed and for a number of years served as a guide to shipbuilders in the design and construction of tankers intended to be classed at Loyd's.

Within a comparatively short time after this, the Bureau Veritas, apparently profiting by this paper, published rules for tankers, and the American Bureau of Shipping published their first rules in 1902, but the first rules of Lloyd's did not appear for general use until 1909.

Both Bureau Veritas and the American Bureau recommended three and one-half diameters at the start, while Lloyd's specified one more rivet in a frame space than required for water-tight spacing resulting approximately in three and one-half diameters. According to the recollection of the writer there was a period when Lloyd's practically decided not to class any more converted vessels, but both workmanship and details of construction must have improved, as many converted vessels have since been classed and have given good service. Evolution was a slow process, and no doubt in numerous cases the true cause for failure was not recognised. Mr. Martell realised this when he wrote his paper and provided for tanks not over 24 ft. in length, increased stiffeners and brackets, as well as closer spacing of rivets. Had the earlier tankers been better designed as regards tanks, stiffeners, brackets and compensation, where needed, the question of rivets and spacing of rivets for oil-tight work might possibly have received somewhat less attention during these troublous times. This appears to be a reasonable inference from the fact that so many converted tankers have since given long and satisfactory service.

Rivets in the shells of the early tankers were continually getting loose and leaky, while it is very rare that the shell rivets spaced for water-tight work of later converted vessels, where the interior details of construction were in accord with Mr. Martell's recommendations or classification rules, showed leaks. The comparatively slight variation in the spacing of shell rivets would not account for this great difference and must be attributed somewhat to improved details of construction and, in a measure superior workmanship.

That oil-tight work should be double riveted was an accepted rule. This is still the general requirement, but single riveting is now permitted in the seams of double bottoms intended for carrying fuel oil. This concession was not made until after many vessels in commission had been converted to carry fuel oil in their double bottoms with single-riveted seams and their class continued. The writer recalls a large vessel on the stocks with tank top required to be double riveted to carry fuel oil, while at the same time an old vessel lying in a wet slip alongside was being fitted to carry fuel oil in the double bottom where the tank top was single riveted.

Both new and old single-riveted tank tops, where fuel oil is carried in double bottoms, have proved a success. Why should there be any greater risk in single-riveting the seams for decks and trunks of tankers, which are subject to less test head and deflection, especially where the spacing is made closer for oil-tight work? This is a parallel case to double bottoms above noted, for both Lloyd's and the American Bureau have vessels on their books which have been fitted with deep tanks for fuel oil, retaining the original single-riveted decking. This point has been discussed with representatives of both the above societies and one of the largest shipowning companies, who agreed that there would be no real objection with crude oil.

Just how far this argument could be carried for tankers intended or liable to carry bulk gasoline or other light distillates is an open question. If single-riveted seams are tight for crude oil, would they be as tight or rust up tighter with gasoline? Lloyd's do not permit gasoline to be carried in single-riveted double bottoms, but it is not known whether or not it would be permitted even with double-riveted seams with dry cargo above.

The writer was closely associated with the conversion of three passenger steamers to carry about 18,000 barrels of fuel oil in deep tanks forward of the fire room. The vessels had double bottoms which were opened so as to form part of the deep tanks, but the water-tight divisions in the double bottom did not coincide with the tank bulkheads and a portion of the double bottom under each tank formed a part of an adjoining deep tank. In other words, the transverse bulkheads extended, so to speak, under the next tank to the first double-bottom division and then down to the keel, the new part above double bottom being double riveted and the horizontal part, or what was the original double bottom, being single riveted. The after tank extended in this way under the forward fire-room. These vessels have given excellent service, notwithstanding they were built during a strike where the best work could not be expected.

It is not concluded from this that it would be advisable to single-rivet transverse bulkheads in tankers, but with a view to eliminating possible unnecessary expense, it might be well worth considering whether or not there would be serious objection to single riveting the longitudinal seams of centre-line bulkheads with the exception of the lower seam. A cargo is sometimes made up of more than one kind of oil, and it is therefore important that the transverse bulkheads be absolutely tight, but different kinds of oil have seldom been carried on opposite sides of the centre-line, and it would appear that a single-riveted longitudinal bulkhead would fulfil every function the trade demands.

As noted above, Lloyd's in their first announcement, more or less official, recommended three diameters for all oil-tight spacing. This was, in some cases, applied literally. Two vessels were converted in the vicinity of New York to carry oil in bulk, on which a spacing of three diameters was required in both rows of rivets in the flanges of single 5 in. by 5 in. bulkhead bounding bars, which both crowded the rivets and unnecessarily impaired the strength of the shell plating. Classification societies now allow a spacing of five diameters connecting bulkhead bounding bars to shell.

Lloyd's formerly recommended single double-riveted bulkhead bounding bars, but later gave the builder the option of using double single-riveted bars. The general practice now is to use double single-riveted bars with countersunk heads and points and bars caulked on both flanges on each side. The writer is inclined to favour single double-riveted bounding bars and pan-head rivets in standing flange with caulking on one side because it is believed this lends itself to cheaper and better workmanship and would insure the parts being drawn up more closely. Countersunk heads are, of course, unavoidable in the shell flange. On the Clyde, bulkhead bounding bars are frequently hydraulically riveted on the ground, using pan-head rivets and finishing with snap heads and points. Similar practice is universally followed in this country in the case of locomotive oil tenders and tank cars. Snap rivets driven by hand are also satisfactorily used in the construction of oil storage tanks.

There are two vessels now building for the same owner in different yards with double single-riveted bulkhead bounding bars with countersunk head rivets where in one case every rivet is required to be caulked head and point before testing, while in the other case none of the rivets are being caulked before testing. Pan-head rivets are used in the bulkhead stiffeners and are not required to be caulked before testing, which seems to indicate that it is considered the countersunk head rivet requires more doctoring.

In the case of another vessel now building the inspectors are instructed that rivets are to be caulked before testing, in bulkhead bounding bars, heads and points, in all four flanges, also rivet points through bulkheads in clips connecting longitudinal brackets to bulkheads, while in the same instructions it is recommended that as few rivets as possible be caulked before the water test, as it is desired that the rivets be driven in such a manner as to be tight without caulking.

Where double bounding bars are fitted, careful workmanship is necessary to insure the two shell flanges lining up perfectly for intimate contact. To overcome this difficulty and with a view to better and more economical work, T-bars have in some cases been used, although the present available 6½-in. by 6½-in. T-section does not provide sufficient width of shell flange on that side on which the bulkhead plating connects to the standing flange for best spacing of the rivets. A more general use of this type of bounding bars has been recommended by some owners, and with this in view two of the large shipbuilding concerns have without success urged the steel companies to roll a larger section. Conditions, however, would be substantially the same as with single bounding angles. Pan-head rivets could be used except in one flange, three-ply work would be eliminated, and only two edges would require caulking. A single angle as recommended above would have the same number of rivets, the same amount of caulking, and be more easily set.

In gunwale bars, Lloyd's require four and one-half diameters for water-tight work and five diameters for oil-tight work, which does not seem consistent. In a recent case, 1-in. rivets were spaced five diameters in a 5-in. by 5-in. gunwale bar for oil tight work and appeared to be too crowded for the width of flange and size of rivets. Probably a larger bar or six diameters would have presented a better appearance.

The following table gives, for a number of selected parts, the rivet spacing recommended by Mr. Martell in 1894, for oil-tight work, and present requirements for both oil and water-tight work of Lloyd's, American Bureau, United States Navy and British Admiralty.

	Martell, 1894	Lloyd's 1919–20 Rules.		American Bureau 1919–20 Rules.		U.S. Navy.		British Admiralty.	
	O. T.	O. T.	W. T.	O. T.	W. T.	O. T.	W. T.	O. T.	W. T.
Shell plating seams	3	3½	4	3½	4½	3½	3½–5	4	4–4½
Deck plating seams	3	3½	4½	3½	4½	3½	3½–5	4	4–4½
Bulkhead plating seams	3	3½	4½	3½	4½	3½	3½–5	4	4–4½
D. B. plating seams	3	3½	4	3½	4½	3½	3½–5	4	4–4½
Tunnel plating	3	3½	4½	3½	4½	—	—	4	4–4½
Frames to shell	6	6	7	6	*	8	—	4	7–7½
Deck bars	—	5	4½	—	—	—	4½	4	4½
Bulkhead bounding bars	3	5	5	5	5	5	5½	4	4½
Bulkhead stiffeners	6	6	7	†	†	6	6	6	7
Tunnel stiffeners	6	6	7	7	7	—	—	6	6
Shell butts	3	3½	3½	3½	4½	3½	4½	4½	4½–5
Deck butts	3	3½	4	3½	4½	3½	4½	4½	4½–5
Bulkhead butts	3	3½	4½	3½	4½	3½	4½	4	4½–5
D. B. butts	3	3½	4	3½	4½	3½	4½	4	4½

* 7 up to 27-in. frame spacing. 6 above 27-in. frame spacing. 5½ in. deep tanks.

† 7 generally. 5½ in. deep tanks. 4 for 15 per cent. length each end.

Conditions briefly referred to above, no doubt, fully justified Mr. Martell in recommending a spacing of three diameters for satisfactory oil-tight work, but better design, construction and workmanship have demonstrated that strong, staunch ships can be built with wider spacing and be suitable for carrying oil in bulk. Scantlings and riveting must be sufficient to resist the stresses brought upon them, and there must be no slipping of the joints. When this condition is fulfilled the work should be oil-tight whether the spacing is according to present oil or water-tight practice. It will be noted in connection with merchant vessels converted to carry cargo or fuel oil that the spacing is generally four and one-half diameters in the shell.

If oil-tight work depended less on the strength of the riveted joints and of the structure as a whole, and to a greater extent on spacing that would permit caulking without the edge raising, wider spacing could be used. Work that might be tight under static head would not necessarily be tight on parts subject to the working stresses of a vessel in a seaway, but might on certain parts where these stresses were in a measure absent. Any design, spacing or workmanship, which will not permanently prevent the joints from slipping will not remain oil-tight.

The extensive use of oil for fuel in naval vessels during the last few years has brought up for consideration and settlement many problems in design which did not exist in coal-burning vessels. In vessels of great length, such as scout cruisers and battle cruisers, longitudinal bulkheads are used as strength members. The riveting connections in these bulkheads must be designed to obtain maximum strength, and therefore the riveting should not be so closely spaced that more material is punched out of the plating than allowed in the calculations, without compensation. If, however, these bulkheads form boundaries of oil tanks, it becomes a matter of importance, when transverse bulkheads join the longitudinal strength bulkheads, to avoid too close spacing in the bounding bars. If the strength bulkhead is designed for a spacing of six diameters for rivets in stiffeners and oil-tightness demands five diameters at a transverse bulkhead, it becomes necessary to introduce compensating liners which add to the weight and, on account of the extra thickness of plating, increase the difficulty of making the structure tight.

The Hull Division of the Philadelphia Navy Yard recently made a test on an experimental box to determine if a six-diameter spacing of rivets would be satisfactory under the conditions as stated above. It may naturally be expected that a wider spacing for oil-tight work can be used where the bulkheads are close together, where the stresses due to wash are not severe, and where alternating stresses are of secondary consideration. Six diameters might be quite suitable on a deck near the neutral axis, but unsuitable for parts subject to stresses resulting from the vessel working in a seaway, or from shocks of gunfire or explosion. In this test it was found that the caulking of bounding bars to heavy bulkheads was satisfactory under a 60-ft. head with a six-diameter spacing in the connection of transverse to longitudinal bulkhead and five-diameter spacing in bar connecting to the shell. No gunning was used and no special effort made to have the box absolutely tight on the first test. A similar tank was also recently tested at the New York Navy Yard to demonstrate the efficiency of six-diameter spacing for T-bar stiffeners and for bounding bars to bulkheads. The tank was first subjected to a test head of 65 ft. of water and found to be tight; then to a 24-hour endurance test with oil at the same pressure. Then the pressure head was increased to 93 ft., which pressure was maintained for 4 hours without leaks.

The results of the tests appeared to indicate that in fairly heavy plating, where the members are not under the influence of other stresses than those due to head, six diameters are suitable. The thickness of angle bars, it was suggested, should preferably be not less than ⅝ in. It is understood that further tests were directed to be made on experimental tanks at navy yards, as the navy contemplated revising its rules for oil-tight riveting due to the very considerable increase in amount of oil-tight work involved by new construction. A description of these tests in greater detail would be interesting, but, unfortunately, full particulars are not at hand.

It has been the practice in naval work to use a spacing of three and one-half diameters for oil-tight work in seams and straps, four diameters in angles to plates including staples, and four and one-half diameters on bulkhead stiffeners if caulked oil-tight. This is a closer spacing than is required for water-tight work. Experience in the construction of oil tanks in double bottoms seems to indicate that, with ordinary good workmanship, water-tight spacing will be satisfactory for oil. While the naval authorities are not prepared to make the spacings the same, a compromise has been made allowing a somewhat greater spacing than called for by the navy rules for oil-tight work. For single riveting three and one-half diameters are retained, but four and four and one-half diameters, depending on the thickness of the plates, are now accepted; five diameters are used in bounding bars of oil-tight floors.

One of the larger builders, as a result of mathematica analysis, has suggested the following spacing as permissible, provided that considerations other than oil-tightness did not determine the spacing:—

Diameter of Rivet.	Thickness of Plating.	Spacing in Diameters.
In.	In.	
½	⅜	3·6
⅝	½	4·2
¾	⅝	4·9
1	¾	5·6
1¼	1	6·3
1½	1¼	7·0

The above spacings were based on the supposition

that 3¼ in. diameters were satisfactory for a 10-lb. plate using ⅞-in. rivets, and assuming that the deflection of the plate edge caused by caulking probably varies as the ratio of the fourth power of the distance between rivets to the fourth power of the thickness of the plating, and that the extension of the rivet varies as the ratio of the distance between rivets to the area of the rivet. In order to make practical use of the above it was suggested that water-tight spacing be used for rivets in oil-tight work on naval vessels.

A naval constructor stationed at the same yard carried the investigation further by considering the deflection that is caused by caulking and by the amount of general deflection of plating due to water pressure, and suggested that based on the assumptions made the following spacing would be satisfactory: 15-lb. plate, 4 diameters; 20-lb. plate, 4·5 diameters; 25-lb. plate, 5 diameters; 30-lb. plate, 5·3 diameters; 35-lb. plate, 5·6 diameters.

The above tables were deduced without reference to strength of joint, and it was pointed out that this consideration might be more important than questions of tightness. For ¾-in. rivets in 10-lb. plating it was shown that approximately 0·006 in. is the deflection of amount of seam that can be caulked off without exceeding the elastic limit of the material. The stress on the rivet for such caulking was found to be very moderate.

The analysis used in deriving the above tables of rivet spacing for oil-tight work was made to confirm a theory that every unnecessary rivet is a possible source of leakage and that for heavy plating a wider spacing would be permissible but considered only the stresses on the plating and rivets due to caulking to the exclusion of the more complex stresses experienced under service conditions.

For thin plating, where large rivets in relation to thickness are used, the diameter is based more nearly upon theoretical considerations, but if the same considerations were followed in determining the diameters for thicker plates, the rivets would exceed the limit practicable to drive, and spacing based even on using the same number of diameters would at some point become greater than indicated in the tables. Thick plates, however, are used where greater strength is required, and as the rivets used are much smaller in relation to thickness a greater number is necessary to develop the strength of the plating. The uniform spacing in diameters adopted in practice, substantially, for all thicknesses of plating, is a great convenience, and it is only necessary to increase the number of rows of rivets where greater efficiency of joint is desired. If the spacing suggested in the above tables is suitable for oil-tight work, it might be necessary to increase the number of rows to insure proper strength and friction of the joint, in which event there would be an increase in weight and the attempt to reduce the number of rivets defeated.

THE CONSTITUTION OF THE ALLOYS OF ALUMINIUM AND MAGNESIUM.*

By D. HANSON, M.Sc., Member, and MARIE L. V. GAYLER, B.Sc., Member.

(*From the National Physical Laboratory.*)

(*Concluded from page* 791.)

Determination of the Solidus.—For the determination of the solidus the same general method was adopted throughout the whole series of alloys. It is obvious that if solidification of the alloys takes place by the separation, at different times during the process, of solid of varying composition, then the temperature at which melting commences on reheating will depend on the properties of the most fusible part of the alloy. In many cases, however, especially in the case of phases which consist wholly of solid solution, the attainment of equilibrium will alter these properties, and a different solidus temperature will be obtained. As a rule it may be said that an alloy which has not attained equilibrium will have the lower solidus. The authors are of the opinion that, for solidus determinations, the fact that the alloys should be in equilibrium has not been fully appreciated, for the time taken to attain equilibrium is greater than is generally supposed. In the determination of the solidus all the alloys used have been first submitted to a long annealing process, lasting for many hours (generally some days) at a temperature close to the eutectic temperature. In the case of the alloys of this system 420 deg. C. was adopted throughout, as being convenient over the whole range of composition. This treatment was always followed by quenching in water, and the microstructure was examined after the treatment. The alloys were then placed in the Rosenhain quenching furnace and heated to successively higher temperatures, held for half an hour, and quenched. The sections were then examined under the microscope to see whether they had been molten at the moment of quenching. The temperature intervals between successive heatings was 10 deg. C. in the alloys rich in aluminium or magnesium, where the solidus was steep, and 1 deg. C. over the centre portion of the diagram, where a much more accurate determination of the solidus was necessary. When possible the specimens used in these experiments had a hole drilled into them, into which a thermocouple was loosely inserted. Alloys containing between 40 per cent. and 70 per cent. magnesium were so brittle that it was not possible to drill them, since they flaked and crumbled under the pressure of the drill. For these alloys a thin-walled hollow cylinder of aluminium was constructed, the walls being perforated with a large number of holes. This was coated with a "wash" of alundum cement and the alloy under investigation was inserted, the couple being held in contact with the specimen by a wad of ignited asbestos wool placed in the mouth of the cylinders. For the alloys containing between 40 per cent. and 70 per cent. magnesium, the temperatures were measured by means of an iron-constantan thermocouple, which had previously been very carefully calibrated over the range 350 deg. C. to 450 deg. C. This couple was used on account of its large E.M.F., since the highest possible accuracy of temperature measurement was required in the investigation of the alloys in this portion of the diagram.

Some difficulty was at first experienced on account of loss of magnesium in these alloys, when they were heated *in vacuo*. The first samples used developed white-etching borders on the outside of the sample and along the walls of the cracks, which were a common feature in all these specimens. These borders could only be attributed to loss of magnesium. Confirmation of this was obtained when it was observed that the asbestos wool packing was coloured black after the experiment; on examining this wool it was found to contain appreciable quantities of metallic magnesium. This trouble was overcome by carrying out the heating under a partial vacuum only, more complete evacuations being carried out for the purposes of quenching only a few moments before admitting water to the furnace. In the case of alloys near the ends of the diagrams, a platinum-iridium couple was used. The detailed results of these experiments were given in an appendix to the paper. Alloys which had been quenched from above the solidus possessed a characteristic duplex structure, which was readily recognised. The appearance of such alloys is shown in Fig. 18 and Fig. 19. Fig. 18 shows alloy AM_{36}, as quenched from 580 deg. C. When previously quenched from 563 deg. C. the alloy was homogeneous. The appearance of an intergranular film of "quenched liquid" in the photograph indicates that the solidus in this alloy lies between 563 deg. C. and 580 deg. C. Fig. 19 shows alloy AM_{45}, as quenched from 452 deg. C.; when previously quenched from 451 deg. C. it appeared homogeneous. This structure is shown in Fig. 20, which represents the same alloy quenched from 440 deg. C.; the dark parts in this specimen represent holes in the surface, which were a common feature in alloys which had been frequently quenched. The difference in the etching properties of specimens quenched above and below the solidus is however, striking. The solidus curves of the alloy, are shown in Fig. 4 and Fig. 21, Fig. 21 being a large scale diagram of the centre portion of the system. The data from which the curves are plotted are also shown on the diagrams, those points marked by triangles representing temperatures at which the alloys were solid, and those marked by squares representing points at which liquid was present in the alloys at the moment of quenching.

With regard to the solidus of the alloys rich in aluminium and magnesium at the end portions of the diagram, no comment is necessary. The solidus appears to be represented by a straight line joining the end of the eutectic line to the melting point of the pure metal. In the centre portion of the diagram, however, an unusual feature requires some comment. The results of cooling curves indicate a maximum in the liquidus between 50 per cent. and 55 per cent. magnesium. The actual position of the maximum was not indicated more definitely, since alloys having compositions within this range all solidified at the same temperature (within 1 deg. C.). Moreover, there was little on the cooling curve to suggest a longer freezing range in any one alloy than in any other. It was thought that the maximum probably indicates the existence of a compound Al_3Mg_4, which contains practically 54 per cent. magnesium. It was hoped that a careful determination of the solidus would indicate more clearly the exact composition of the compound. The liquidus and solidus appear to coincide at about 56 per cent. to 57 per cent. magnesium. The alloys AM_{56} and AM_{57} appear to have a constant melting point, so far as can be seen from the results which are shown in Fig. 21. Alloy AM_{54}, which has a composition

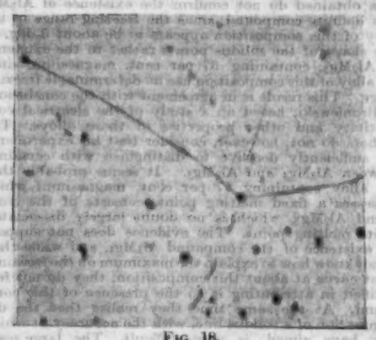


FIG. 18.
AM_{36}. Showing liquid appearing between temperatures 563° C. and 580° C. Etch. 1% alcoholic HNO_3. × 600.

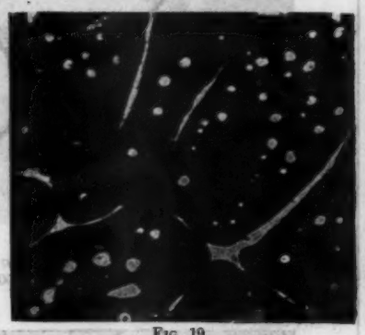
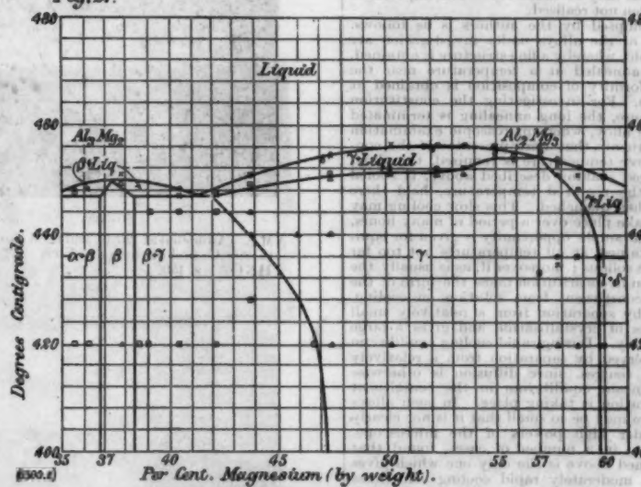


FIG. 19.
AM_{45}. Quenched from 452° C.
Etch. 1% alcoholic HNO_3. × 150.

FIG. 20.
$AM_{45}B$. Annealed for 9 days at 440°C.
Etch. 1% alcoholic HNO_3. × 220.

Fig. 21.



(6300.1)

* Abstract of a paper read before the Institute of Metals, at Barrow-in-Furness, on September 15.

practically identical with Al_2Mg_4, has a freezing range of about 5 deg. C. In making these experiments the authors realised that the measurement of the temperature of small specimens to the accuracy required was not simple. The measurements were, however, carried out with the greatest possible care, and they think the temperatures given are accurate to a sufficient degree to establish the shape of the solidus with an error of not more than ± 1 deg. C. at any point. The data obtained do not confirm the existence of Al_2Mg_4 as a definite compound, since the freezing range of the alloy of this composition appears to be about 5 deg. C. The shape of the solidus points rather to the existence of Al_2Mg_3, containing 57 per cent. magnesium, since the alloy of this composition has no determinable freezing range. This result is in agreement with the conclusions of Broniewski, based on a study of the electrical conductivity and other properties of these alloys. The authors do not, however, consider that his experiments are sufficiently decisive to distinguish with certainty between Al_2Mg_4 and Al_2Mg_3. It seems probable that the alloy containing 57 per cent. magnesium, which possesses a fixed melting point, consists of the compound Al_2Mg_3, which is no doubt largely dissociated at its melting point. The evidence does not support the existence of the compound Al_2Mg_4, and while they do not know how to explain the maximum on the freezing-point curve at about this composition, they do not feel justified in attributing it to the presence of this compound. At the same time they realise that the determination of a solidus line, with the accuracy at which they have aimed, is very difficult. The large-scale diagram of the middle portion of the system (Fig. 21) does not suggest errors in the temperature measurements sufficiently great to throw doubt on the general accuracy of the diagram.

Constitution of the Solid Alloys.—So far, the constitution of the alloys has been described only from the commencement of solidification to immediately below the solidus of the alloys. Further experiments were undertaken with a view to determining what changes take place after solidification is complete. Thermal curves had not given any indication of changes below the temperature of the solidus, and the main object of this part of the investigation was the determination of the mutual solubilities of the different constituents in one another at different temperatures.

The method usually adopted to achieve this object is to anneal specimens of the alloys at the temperature at which the constitution is to be studied, followed by quenching to preserve the structure as it existed at that temperature. In many cases this method is open to considerable objections. Diffusion in solid metals is slow, and this is specially so at temperatures much below the solidus of an alloy. If the structure of a metal is at all coarse, and equilibrium has not been obtained during solidification, long periods of annealing are necessary to secure uniformity of composition in the different phases, even if the annealing temperature is near that of the solidus. With very fine structures many hours are required; with coarser structures, days or even weeks may be necessary. The importance of this point is often not realised.

The method adopted by the authors is as follows. Small specimens of the alloys under investigation are cast in a chill mould, whereby a fine structure is obtained. These are then annealed at a temperature near the solidus until uniformity of composition is obtained at that temperature. For investigating the constitution at that temperature, the long annealing is terminated by quenching the alloy, when microscopic examination shows the constituents that were present. If the constitution at a lower temperature is required, the alloy, after the prolonged soaking described above, is cooled very slowly to the required temperature, held there for a time, and then quenched. This slow cooling may with advantage take place over a period of many hours, during which time ample opportunity is given for equilibrium to be attained at all temperatures not too far removed from the solidus; moreover if, as is usually the case, the alteration in constitution takes the form of the separation of a constituent from solution on cooling, this takes place by separation from a relatively small number of centres of crystallisation and gives a large structure in the alloy. During rapid cooling equilibrium can only be preserved by separation from a relatively large number of centres, since diffusion is otherwise too slow to maintain equilibrium in the constituent from which separation is taking place. In such alloys the microstructure may be so small that it is not clearly defined even under high powers of the microscope. The authors have, in a number of cases, found that the method outlined above is the only one which gives decisive results; moderately rapid cooling sometimes eads to the precipitation of a constituent in so fine a form that it cannot readily be identified, while simple annealing at a temperature well below the solidus takes so long, if equilibrium is to be attained, as to be impracticable. For carrying out slow cooling experiments the thermostat furnace, already referred to, has been adapted. This can be arranged to give any required rate, from 1 deg. C. per day upwards. In practice, a convenient method is to carry out the slow cooling over night, since the thermostat, once it is set, requires no further attention. Much time can be saved in this way. The results of experiments to determine solid solubilities and phase-field boundaries in the solid alloys are given in a tabular appendix to the paper, and are plotted on the constitutional diagrams, Figs. 4 and 21. The triangles on these diagrams show points at which the alloys are homogeneous, and the squares represent points at which they are duplex. The actual experimental data on which the boundary lines are based are are thus shown clearly.

A number of photomicrographs may be shown to illustrate the results given. Fig. 22 represents an alloy containing 88 per cent. magnesium, as quenched after prolonged annealing at 420 deg. C. This may be compared with Fig. 17, which contains 90 per cent. magnesium and has had the same thermal treatment. Small particles of γ appear in AM_{88}, but not in AM_{90}. AN_{90} in the chill cast condition is shown in Fig. 23; the amount of γ which has gone into solution on annealing is considerable. Figs. 24 and 25 represent respectively the alloys containing 60 and 62 per cent. magnesium as quenched after prolonged annealing at 420 deg. C. Alloy AM_{60} consists of homogeneous alloy γ, AM_{62} of γ with particles of β. Fig. 26 shows the microstructure of alloy AM_{10} which had been cooled slowly from 420 deg. C. to 300 deg. C. and quenched after prolonged annealing at the higher temperature. At 420 deg. C. it was found to be homogeneous; after slow cooling to 300 deg. C. fine particles of β were found to have been precipitated from solid solution. These appear as fine dots on the photomicrograph. The boundary between the $\beta + \gamma$ and γ fields at first presented some difficulty. As a result of annealing experi-

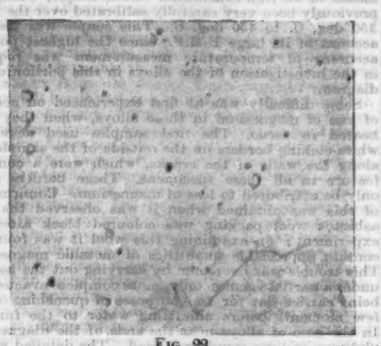


Fig. 22.
AM_{88}. Annealed for 44½ hrs. at 420° C. Etch. 1% alcoholic HNO_3. × 150.

Fig. 23.
AM_{90}. Chill Cast. Unetched. × 150.

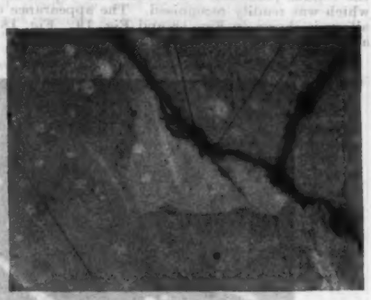


Fig. 24.
AM_{60}. Annealed for 70 hrs. at 420° C. Etch. 1% alcoholic HNO_3. × 150.

Fig. 25.
AM_{62}. Annealed for 70 hrs. at 420° C. Etch. 1% alcoholic HNO_3. × 150.

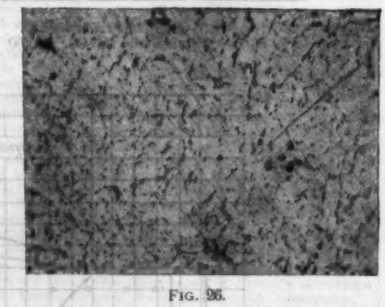


Fig. 26.
AM_{10}. Annealed at 420°C. and then slowly cooled to 300°C. and quenched. Etch. 1% alcoholic HNO_3. × 150.

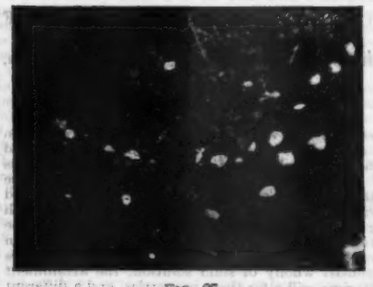


Fig. 27.
AM_{44}. Quenched from 428°C. Etch. 1% alcoholic HNO_3. × 200.

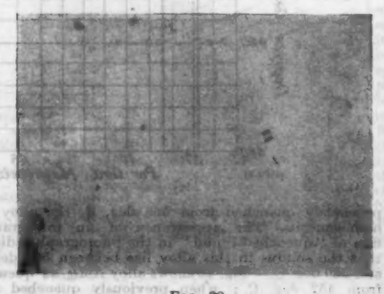


Fig. 28.
AM_{44}. Annealed for 9 days at 440°C. and quenched. Etch. 1% alcoholic HNO_3. × 200.

Fig. 29.
AM_{44}. Annealed for 9 days at 440°C and quenched. Etch. 1% alcoholic HNO_3. × 200.

(Figs. 24 to 29. Reduced by One-quarter.)

ments carried out at 420 deg. C., it was thought that the limit of solubility of β in γ immediately below the solidus lies at about 47 per cent. magnesium, since after annealing at this temperature followed by quenching, AM_{47} contained a little β, while AM_{48} was homogeneous. On reheating alloys consisting of $\beta + \gamma$ for solidus determinations, it was observed that the amount of β decreased as the temperature was raised. For example, Fig. 27 and Fig. 28 show the structure of alloys AM_{44} after quenching from 428 deg. C. and 440 deg. C. respectively. At 428 deg. C. the alloy contains some β (white); at 440 deg. C. it is homogeneous γ. The change in the etching properties of the γ constituent with the disappearance of β will be noticed. In the case of alloy AM_{42}, melting began before disappearance of the β constituent was complete: but the extent to which its solution in (or transformation into) γ takes place on heating in this range may be judged by a comparison of Fig. 29 and Fig. 30, which represent the alloy as quenched from 440 deg. C. and 435 deg. C. respectively. This solution of β in γ over this range was found to be quite reversible, and was not due to want of equilibrium in any of the alloys. Reprecipitation of β from solution on cooling is illustrated by Fig. 31, which shows alloy AM_{48}. This alloy had been annealed at 420 deg. C. for 66½ hours, at which temperature it was known to be homogeneous, and had subsequently been cooled to 300 deg. C., from which temperature it was quenched. Precipitation has taken place from a large number of centres, with the production of small "globules" of β Some further reference to these alloys is found in the appendix, in which the etching properties of the alloys of this series are discussed.

In conclusion, the authors wish particularly to express their indebtedness to Dr. W. Rosenhain, F.R.S., for his continued interest and encouragement during the course of the research.

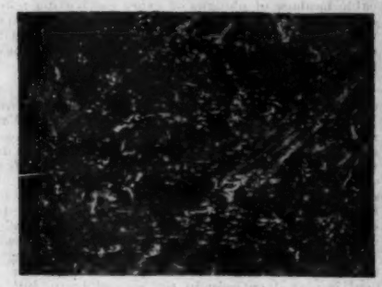


FIG. 30.

AM_{42}. Quenched from 435° C.
Etch. 1% alcoholic HNO_3. × 150.

FIG. 31.

AM_{48}. Quenched from 300° C.
Etch. 1% alcoholic HNO_3. × 200.

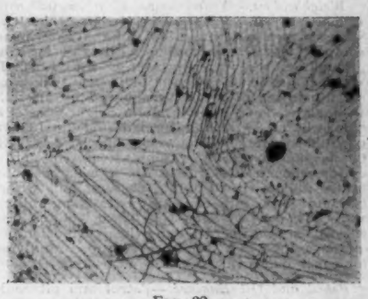


FIG. 32.

AM_{60}. Annealed specimen showing film.
Etch. ·5-·7% alcoholic HNO_3. × 150.

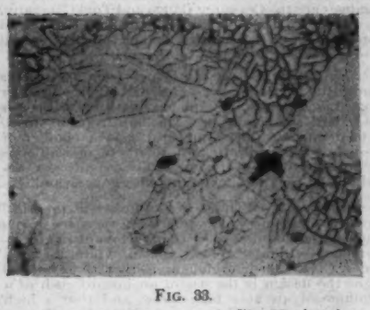


FIG. 33.

AM_{60}. Same specimen as in Fig. 32, showing broken film. Etch. ·5-·7% alcoholic HNO_3. × 600.

FIG. 34.

AM_{48}. Annealed for 9 days at 440° C.
Etch. 1% alcoholic HNO_3. × 200.

FIG. 35.

AM_{48}. Annealed for 9 days at 440° C.
Etch. 1% alcoholic HNO_3. × 200.

(Figs. 30 to 35. Reduced by One-quarter.)

APPENDIX.

Etching Properties.—The alloys over the whole range up to about 85 per cent. magnesium took a brilliant polish quite easily, but alloys of 85 per cent. magnesium and upwards, when washed with water on the pad, showed signs of effervescence. Pits were formed in these alloys which increased with the use of more water; using very little water, scarcely any pitting occurred. These alloys, however, presented other difficulties on etching. Using a 0·5 per cent. to 0·7 per cent. alcoholic solution of nitric acid, large crystals could be seen with the naked eye on the surface of the specimen, but when examined under the microscope, the whole surface was covered with apparently small "crystals" inside the large boundaries (see Fig. 32). Each so-called "crystal" appeared to have the same orientation as others in the large crystal, but those in the adjacent large crystals had different orientation. It was noticed that the boundaries of the large crystals appeared in some places but were very indistinct and that the so-called "crystals" were not terminated by such boundaries. It was, therefore, concluded that these could not be real crystals, but must be due to some film which had been formed during etching. To verify this, a specimen was etched by rubbing it on chamois leather (straight from the emery papers), moistened with the etching reagent 1·0 per cent. alcoholic nitric acid; large crystals boundaries were etched up and no small crystals (see Fig. 17). Furthermore, a specimen was examined under the microscope while being etched, and it was noticed that a film seemed to be formed which moved over the surface. The surface was washed with alcohol without letting the etching solution dry on it; no "crystals" were formed. The alcohol was then drawn off, and it was noticed that as it evaporated the "crystals" appeared (Fig. 33). It was, therefore, concluded that the structure was due to a film which was formed on the surface of the specimen during etching.

All alloys with composition 85 per cent. to 100 per cent. magnesium were polished and etched in the above manner, so as to avoid the formation of this film. Alloys up to 85 per cent. magnesium took a brilliant polish quite easily, and were finally etched with a 1·0 per cent. alcoholic solution of nitric acid. Several etching solutions were tried, consisting of various strengths of sulphuric acid, ammonium chloride, and hydrochloric acid, both in alcohol and water; but the reagent chosen was found to be far the most satisfactory. The magnesium rich constituent is attacked first throughout the series.

In the range between 46 per cent. and 51 per cent. magnesium some peculiar etching effects take place. It has already been noted that this range forms a homogeneous solid solution and that the crystals became tinted in varying degrees. After annealing AM_{48}, AM_{49}, AM_{49}, for nine days at 440 deg. C., it was noticed that the specimens showed a curious triangular structure in small patches. This structure was very fine and had not been noticed on previous annealings. Alloy AM_{49} was practically made up of the structure, as shown by Fig. 34. These triangles were alternately light and dark, but the contrast is not so great as shown in the photograph. The triangles seem also to be oriented according to large crystals, for in the photograph one can see the change in the orientation at what is obviously a crystal boundary.

AM_{49} showed, however, a much coarser structure in a few places, which definitely proved that large crystals tend to have a triangular shape, but owing to lack of opportunity for free growth that characteristic is suppressed (Fig. 35). AM_{51} also showed signs of this coarser structure.

During the solidus determination of AM_{48}, the apparent size of the small triangles was noted to see if quenching at successively high temperatures caused an increase or decrease in size. There is little justification for saying that the structure was refined or coarsened.

DRYING BY ELECTRICALLY-SUPERHEATED STEAM.

IN some countries, notably in Switzerland, the scarcity of coal due to the war has led to the use of electric heating for purposes for which the potential resources of hydro-electric energy would hardly have been utilised under normal conditions. On page 170, vol. cix, and on page 563 of the current volume of ENGINEERING, we described some types of electrically-heated steam boilers used in Switzerland. We now wish to refer to the drying ovens for foundry-moulds and cores, and for peat and vegetables which the Maschinenfabrik Oerlikon, known as the M.F.O., has introduced. In describing this novelty in the *Schweizerische Bauzeitung* of November 6 and 13, Mr. J. Karrer, of Zürich, distinguishes three types of drying. In ordinary hot-air drying, air is drawn in by a fan and sent through a heater containing, in this case, an electric resistance, and passed over the material to be dried to escape at the far end of the stove. With this simple arrangement the heat generated escapes with the hot moisture, and the thermal efficiency of the process cannot but be very low. Matters are somewhat better in the second or circulation system, in which a damper is placed in the discharge pipe, and most of the hot moist air is sent back to the fan, so that the hot air circulates. The air intake at the fan is kept partly open in order to replenish the moist air discharged. The thermal efficiency of this system should be superior to that of the first method. In the third system, drying by superheated steam, no special air inlet is provided; the air in the oven-chamber is kept circulating by the fan as before, and the water vapour driven off from the material is superheated. An escape opening is provided lest the pressure become excessive. A relatively high thermal efficiency ought to be realisable in this system. This method of drying by superheated steam has not been largely adopted as yet. The material treated may not bear the high temperatures likely to arise, and if the drying is to take place at reduced pressure, and therefore at lower temperatures, special arrangements are required which make the ovens expensive. Drying at the higher pressures also requires special valves.

For these reasons the M.F.O., when first fitting their foundry drying-ovens, previously heated by coke, for electric heating, arranged the intake and outlet in their oven-chamber, of 25 cub. m. capacity, so as to be able to change over from one to the other system. The heater, which is not described by Karrer, was placed in the oven-chamber, the fan motor being mounted outside. Mercury thermometers and thermocouples were fixed at various points to check the temperature distribution. When the oven was charged with 6,693 kg. (nearly 7 tons) of material, the temperature rose within an hour to 300 deg. C., and even to 352 deg. at one point, and the moisture was discharged at 130 deg. In this experiment on the first hot-air system, during which the average temperature was kept steady, the material lost in the first ten hours was 265 kg. of water; the thermal efficiency was about 13 per cent. In another core oven which the M.F.O. supplied for the firm of Wanner and Co., of Horgen, the efficiency rose to 18·5 per cent.

The results suggested a trial of the third, superheated-steam system. In this case the temperature rose steadily during the first ten hours to about 450 deg. C. (the hottest spot to 554 deg.); some resistance was then cut out, and the temperature dropped. The thermal efficiency rose to 30 per cent. The charge of the oven was larger in this instance, weighing nearly 9 tons. With another charge of a little over 7 tons an efficiency of 27 per cent. was reached. On the strength of these experiments the oven in the Horgen works was re

arranged for superheated steam-drying, and the efficiency was raised to 37 per cent., or double that obtained with hot-air drying. It takes about 2·4 k.w.-hours to evaporate 1 kg. of moisture. Much higher efficiencies can hardly be expected considering the heat losses by radiation and conduction, and that not only the articles themselves, but also the trucks and frames which carry them in the oven have to be heated.

In the case of peat, which was next tried, less heat was required for the carriers, and the efficiencies realised were very much higher, increasing to 82 per cent. in fact. Peat is not very important in Switzerland, but the M.F.O. possesses some peat ground, and the determinations made at the Swiss Federal Technical High School showed that this peat, containing 0 per cent., 9·8 per cent., 22·2 per cent., 30 per cent. of moisture yielded respectively 5,390 calories, 4,803 calories, 3,916 calories, 3,593 calories per kg. With 50 per cent. of moisture the calories would probably fall to 2,200. Some of the air-dried peat which the M.F.O. dried in some experiments to which we now pass, was actually of that high moisture content. Superheated steam was used in this case, but the temperature of the steam was not allowed to rise above 130 deg. C. That temperature was reached in about 5 hours, then some resistance was cut out, the whole drying taking 12 hours. The temperature of the discharged moisture kept within 20 deg. or less of the figure mentioned. The peat charges of the oven ranged from 5 tons up to 15 tons, and the highest thermal efficiencies were obtained with the largest charges. The dried peat still contained from 9 per cent. to 20 per cent. of moisture, and it required about 0·23 k.w.-hour to reduce the moisture of 1 kg. of peat from 35 per cent. down to 15 per cent.—relatively satisfactory figures.

In connection with the dessication of vegetables, fruit and other articles of food, which is an industry of some importance in Switzerland, the M.F.O. makes use of a vacuum stove for its own purposes, but apparatus for working at atmospheric pressure is also constructed. In an experiment made with cabbage in a vacuum stove the steam temperature rose to 130 deg., at which it was kept for five hours, the pressure being 700 mm. of mercury. In about three hours the temperature of the discharged moisture rose to 80 deg.; resistance was then cut out. Attention is drawn to the fact that the cabbage retained its green colour. In another experiment grass was dried in five hours, yielding a green hay. The preservation of the colour may add considerably to the popularity of food drying by that means. Karrer does not give any information about the internal arrangements of the ovens or about their insulation. His main object is to draw attention to the possibilities of drying by superheated steam.

Swiss Shipbuilding Yard on the Rhine.—In order to promote navigation on the Middle Rhine, especially between Basle and Strasbourg, a shipbuilding yard has recently been built at Kaiser Augst, near Basle, at the junction of the Ergolz River, which comes from the Jura, and the Rhine. There is another Augst higher up on the Rhine in Aargau. The yard has an area of about 80 m. by 80 m. (roughly, 250 ft.) and has already built four 600-ton barges for the Swiss Schleppschiffahrt Gesellschaft. A paddle-wheel tug, 65 m. (213 ft.) long, 17 m. (56 ft.) beam, is under construction for Messrs. Escher Wyss and Co., who will supply the Zoelly turbine of 1,000 h.p. to drive the wheels by gearing. The draught of this boat is only 0·85 m. (33·5 in.). The dock at the new yard only accommodating vessels 12 m. (39 ft.) wide, the ship will have to be launched without its paddle boxes; these will be completed outside the dock.

Nomenclature of Lubricating Oils.—Specifications and nomenclature of lubricating oils were discussed by William F. Parish at a convention of the Independent Oil Men's Association in Denver, September 29, says *The Iron Age*, New York. The paper was, in part, as follows: Uniformity of name and classification have not been attempted by the petroleum industry as a whole with any lubricating product, excepting oils intended for lubrication of automobile motors. Oils for this service were at first made in only one grade by each manufacturer, and were called by various trade-mark names. Later different grades were found necessary and the terms light and medium, then heavy and extra heavy were used. In 1916 a survey showed that more than 98 per cent. of all the oil marketers in the country had adopted the light, medium and heavy nomenclature, but these names did not cover definite grades of oil, analyses showing considerable overlapping of, viscosity which is the most important feature governing a recommendation of classification. In drawing up the specifications for motor oil for the army the viscosity range for each of the various grades was limited by a War Department specification covering light, medium and heavy oil. Since the armistice these specifications have been rewritten, the final form of April 16, 1920, being but little different from the original specifications, the range being as follows: Viscosity at 100 deg. F., U.S. Saybolt universal test; extra light, 140 to 160; light, 175 to 210; medium, 275 to 310, heavy, 370 to 410; extra heavy, 470 to 520 secs. The Government Specifications further carry out the general idea that oils suitable for internal-combustion engine lubrication would be suitable for the lubrication of steam turbines and air compressors, that is, low carbon and of good emulsion test. The present Government methods employed both by the army and navy in regard to nomenclature and classification of lubricants are sound and proper, and will undoubtedly be generally followed by great American industries. There is no question but that the trend of the times is towards specifications for petroleum products.

CATALOGUES.

Non-Corrosive Metal.—The P. R. Metals Company, Limited, 8, Old Bond-street, London, W. 1, send a leaflet describing their gold colour metal which is non-corrosive, very ductile, capable of taking a lasting polish and suitable for casting, or cold or hot rolling.

Bench Standards.—A pressed steel standard with two legs for making up workshop benches, is shown in a catalogue received from the Standard Pressed Steel Company, Philadelphia, U.S.A. The design is neat and convenient for connecting the planks to complete a bench.

Electric Cables.—A comprehensive and carefully-compiled catalogue of wires and cables for electric light and power has been issued by Messrs. Pirelli, Limited, 144, Queen Victoria-street, London, E.C. 4., who have considerable manufacturing facilities at Southampton, as well as in Italy and Spain.

Aluminium Motor Car Bodies.—A special catalogue dealing with the application of aluminium to motor car body building has been issued by the British Aluminium Company, Limited, 109, Queen Victoria-street, London, E.C. 4, who mention that the ductility of the metal allows graceful lines to be produced. There is much practical information for the workman in the catalogue.

Protective Paint.—A brilliant black anti-corrosive covering for metal, concrete, wood, &c., is described in a catalogue received from the manufacturers, Messrs. Wailes Dove Bitumastic, Limited, 5, St. Nicholas Buildings, Newcastle-on-Tyne. The properties claimed for the material are that it is proof against acid fumes and smoke, and that it adheres closely and thus prevents rusting.

Screw Gauges.—Sets of plug and ring screw gauges made to very fine limits of accuracy and hardened, are listed, with prices, in a brief catalogue received from Messrs Alfred Herbert, Limited, Coventry. The makers of the gauges are the Coventry Gauge and Tool Company. The sizes cover all usual requirements in British standard bolt, pipe, fine and British Association threads, as well as metric threads from 3 mm. to 48 mm.

Reversing Rudders.—A catalogue from Kitchen's Reversing Rudder Company, Limited, 711, Royal Liver Building, Liverpool, states dimensions and prices for their standard small sets for propellers from 10 in. to 26 in. in diameter. The same firm send a booklet of testimonials which indicate that this type of rudder is finding a good deal of favour. The small sets are variously fitted for tiller, lever and wheel operation.

Vacuum Cleaners.—Figures of a number of practical comparative tests of their vacuum cleaner are given in a four-page circular issued by the Sturtevant Engineering Company, Limited, 147, Queen Victoria-street, London, E.C. 4. Their argument is that the essential feature of the design is the use of an inward rush of a large volume of air at a high speed, and that a high vacuum in the machine does not produce this effect so well as a very rapid displacement of air which may be created by a comparatively low vacuum.

Steel Works Plant.—A very handsome catalogue of heating plant specially designed for steel works comes from the Wellman, Smith, Owen Engineering Corporation, Limited, Darlaston. Reheating furnaces, soaking pits, gas producers, rolling open-hearth furnaces and metal mixers are the general headings of the catalogue, but practically the whole heating apparatus for steel-making on the most improved systems is included. The firm advises on all the essential requirements for steel-making, supplies drawings for the buildings, excavation or other work necessary for laying down the plant, and is able to deal with the largest orders for equipment for home or foreign installation.

Piston Rings.—Quite a wealth of precise practical information on the subject of pistons and rings for motor vehicles and aircraft engines is given in a catalogue (priced 2*s.* 6*d.*), issued by Messrs. Allen and Simmonds (Reading), Limited, Reading, and similar information relating to steam, oil and gas engines is included in a larger catalogue (priced 12*s.* 6*d.*), from the same firm. The illustrations are adequate for practical use, and the particulars will be helpful for both overhaul and new design work. These catalogues present the results of greater experience than most individual engineers can hope to acquire, especially in these days of specialisation, and should be carefully studied by all interested in the subject.

Small Oil Engines.—Engines for burning cheap grades of oil are being more widely used in small sizes, and the Hamworthy Engineering Company, Limited, 76, Victoria-street, London, S.W. 1, are providing four sizes (brake horse-powers: 2½, 5, 9, and 15) of British manufacture throughout. These engines are of the two-stroke cycle and are made to standard dimensions in all parts and in large quantities, so that considerable orders for the home or overseas markets can be readily executed. The engines are made as complete power units for stationary, semi-portable or portable working, and also in combination with electric generators, air compressors, pumps, or saw benches. Full particulars of weights, dimensions, &c., are given and prices quoted.

Small Tools.—A number of catalogues from Alfred Herbert, Limited, Coventry, show a great variety of tools for machines or machine work. These include dial gauges; standard slip gauges; sets of arbours, collets, end mills and cylindrical side and face mills for milling machines; a remarkably large and fully-dimensioned series of Norton grinding wheels; a very comprehensive series of twist drills, reamers and milling cutters of all kinds, including thread mills, made by Messrs. E. G. Wrigley and Co., Limited, Birmingham; and an exhaustive series of files, fully illustrated and dimensioned, made by Messrs. Joseph Peace and Co., Limited, Sheffield. All these catalogues give the description and particulars required by engineers in clear and well-arranged form.

Agricultural Machinery.—A new self-propelled motor plough capable of cutting two furrows, 10 in. wide, is described in a catalogue received from Messrs. John Fowler and Co. (Leeds), Limited, Leeds. The plough is integral with the tractor which runs on two wheels, 54 in. in diameter, and steering is effected by holding, or retarding one wheel while driving the other. A four-cylinder petrol engine developing 20 h.p. to 25 h.p. drives the machine. Another engine of 60-h.p. is shown on four wheels with an under-drum on a vertical shaft for cable haulage of ploughs or other cultivating machines. A third catalogue shows the cable ploughing steam engine which this firm has developed for many years. All these machines are equipped for rapid and easy handling under the most trying working conditions.

Motor Vehicles.—A six-wheel commercial vehicle described in several catalogues received from the makers, Messrs. G. Scammel and Nephew, Limited, Watford, is made up of a four-wheel vehicle of, more or less, usual form, except that the platform above the driving wheels is fitted with a pivot joint for taking the fore end of a second body having two wheels at its rear end. When assembled there are three pairs of wheels, which may be described respectively as steering wheels, driving wheels and bogie wheels. The gross loaded weight is very equally distributed over the three axles, so that 7½ tons of load can be carried without placing more than the legal axle load on any one axle. The useful load is placed entirely in the second body, but about half its weight rests on the middle, or driving axle. The specification indicates high quality of material and workmanship and careful provision for convenience in working.

Weighbridges.—As early as 1700 loaded carts were weighed by an overhead steelyard to which they were slung by chains. In 1744 John Wyatt invented a compound lever weighbridge with table flush with the ground and the lever projecting into a small cabin sunk a few steps below the ground level. These machines are illustrated in a catalogue issued by Messrs. Henry Pooley and Sons, Limited, John Bright-street, Birmingham, who made their first weighbridge in 1835, and are now able to show a long series of special weighbridges for locomotives, railway rolling-stock, traction engines, motor vehicles, carts, cattle, &c. The largest single-unit bridge weighs a load up to 160 tons, but two-unit and four-unit types are made for extra long rolling-stock, and a special type weighs the separate loads on locomotive wheels, as a means of testing the distribution of weight on the springs. The various types are carefully designed for convenience in use.

Petrol and Oil Engines.—Petrol and oil engines for marine and stationary use are very fully described in an excellent catalogue issued by the Parsons Motor Company, Limited, Southampton. Two sizes of cylinder are employed: 4½ in. by 6 in., developing 7 h.p. on petrol and 6½ h.p. on oil; and 6½ in. by 8 in., developing 15 h.p. on petrol and 12½ h.p. on oil. Power units are built up with one, two, three, four and six cylinders of the smallest diameter, and with two, three, four and six cylinders of the larger diameter; thus providing a full range of powers from 7 h.p. to 90 h.p. Every auxiliary fitting required for home or foreign use may be obtained, and the firm will mount any standard make of dynamo, pump, compressor or other machine on the same baseplate as the engine if desired. These engines are made to accurate standard dimensions, and each part is fully and clearly specified. The firm also send a booklet illustrating applications of their engines to electric welding, fire service, marine salvage, locomotives, stone crushing, disinfecting, aerial rope haulage, general belt drive, &c., besides the other uses already indicated.

Desulphurising of Coke by Hydrogen.—For metallurgists the presence of sulphur in coke is very objectionable as is well known and the trouble is likely to become more serious with inferior coal. Most of the sulphur in the coke comes from the pyrites, and the pyrites can, to a certain extent, be removed by washing the coal. The washing does not affect the organically-bound sulphur, and it barely reduces the sulphur content of the coal by one-half in the best case. Various other means of getting rid of the sulphur have been tried, mainly by converting the sulphur into a compound which can either be volatilised or be eliminated by subsequent leaching. Heating of the coal with steam or air, with chlorine, sodium chloride, carbon monoxide or manganese dioxide has been proposed. None of these proposals have been adopted on a large scale, however, because they are either wasteful or too complicated. In analytical practice coal can completely be desulphurised by hydrogen. For that purpose, the powdered coal is mixed with zinc or some other metal which will generate hydrogen on the addition of hydrochloric acid; this hydrogen changes all the sulphur into sulphuretted hydrogen, which escapes. It occurred to Alfred R. Powell, of the United States Bureau of Mines Experiment Station at Pittsburgh, that coal might be purified of sulphur by passing hydrogen through the coking mass. The experiments so far conducted are promising. But the coal must be heated for 3 hours up to 1,000 deg. C. when hydrogen is used, and for longer periods if coke-oven gas is to be utilised, though some of the reactions take place at a temperature of 500 deg. C. The experiments as yet have only been made on a very small scale, however, so that the practical difficulties remain an unknown factor.